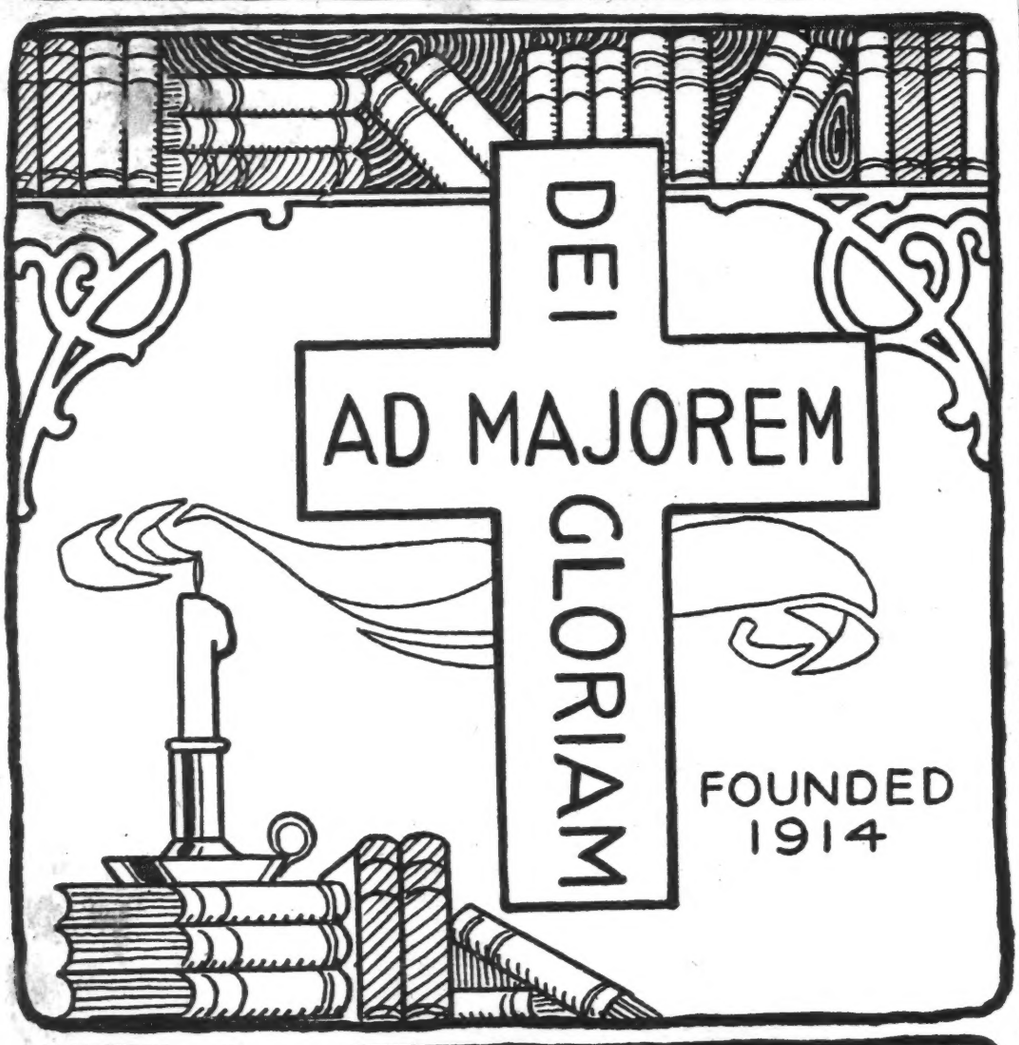
VOLUME 1

BW264
.W458 1810 v.1

School of Theology



THEOLOGICAL LIBRARY
Thursfield Smith Collection, No._____

Wes 296

A SURVEY OF THE WISDOM OF GOD IN *THE CREATION:* OR, A COMPENDIUM OF NATURAL PHILOSOPHY.

IN FOUR VOLUMES.

By JOHN WESLEY, M. A.

THE SIXTH EDITION.

VOL. I.

These are thy glorious Works, Parent of Good,
Almighty! Thine this universal Frame,
Thus wond'rous fair! Thyself how wond'rous then!

MILTON.

DUBLIN:
PRINTED BY R NAPPER, 29, CAPEL-STREET;
And sold at the Methodist Preaching Houses in Town & Country.

1810.

THE

PREFACE.

1. I HAVE long desired to see such a Compendium of Natural Philosophy, as was, 1. Not too diffuse, not expressed in many words, but comprized in so moderate a compass, as not to require any large expense, either of time or money: 2. Not maimed or imperfect; but containing the heads of whatever (after all our discoveries) is known with any degree of certainty, either with regard to the earth or the heavens. And this I wanted to see, 3. In the plainest dress; simply and nakedly exprest, in the most clear, easy, and intelligible manner, that the nature of the things would allow: particularly free from all the jargon of mathematics, which is mere Heathen Greek to common readers. At the same time I wished to see this short, full, plain account of the visible creation, directed to its right end: not barely to entertain an idle, barren curiosity, but to display the invisible things of God, his power, wisdom and goodness.

2. But I cannot find such a treatise as this in any modern, any more than ancient language. And I am certain there is none such in the English tongue. What comes nearest to it, of any thing

I have ſeen, is Mr. Ray's Wiſdom of God in the Creation: Dr. Derham's Phyſico and Aſtro-Theology: Niewentyt's Religious Philoſopher: Mather's Chriſtian Philoſopher, and Nature delineated. But none of theſe, ſingle, anſwers the deſign. And who will be at the pains to extract the ſubſtance of them all, and add the later diſcoveries, of which they had little knowledge, and therefore could take but little notice? This is a deſideratum ſtill; and one that a lover of mankind would rejoice to ſee even tolerably ſupplied.

3. I am thoroughly ſenſible, there are many who have far more ability, as well as leiſure, for ſuch a work than me. But as none of them undertake it, I have myſelf made ſome little attempt in the enſuing volumes. Herein following Dr. Derham's plan, I divide the work into text and notes *. The text is in great meaſure tranſlated from the Latin work of John Francis Buddœus, the late celebrated Profeſſor of Philoſophy, in the Univerſity of Jena, in Germany. But I have found occaſion to retrench, enlarge, or alter every chapter, and almoſt every ſection. So that it is now, I believe, not only pure, containing nothing falſe or uncertain; but as full as any tract can be expected to be, which is compriſed in ſo narrow a compaſs: and likewiſe plain, clear, and intelligible to one of a tolerable underſtanding. The notes contain the ſum of what is moſt valuable, in the above-named writers: to which are added the choiceſt diſcoveries both of our own, and of the foreign ſocieties. Theſe likewiſe, I truſt, are as plain and clear, as the nature of the things ſpoken will allow: although ſome of them, I know, will not be underſtood by an unlearned, or inattentive reader.

* So it was in the firſt edition. Many of theſe are now taken into the text.

4. Mean

4. Mean time I muſt apprize the Reader, that I have ſometimes a little digreſſed, by reciting both uncommon appearances of nature, and uncommon inſtances of art: and yet this is not properly a digreſſion, from the main deſign I have in view. For ſurely in theſe appearances alſo, the wiſdom of God is diſplayed: even that manifold wiſdom, which is able to anſwer the ſame ends by ſo various means. And thoſe ſurprizing inſtances of art do likewiſe reflect glory upon Him, whoſe Spirit in man giveth that wiſdom, whoſe inſpiration teacheth underſtanding.

5. It will be eaſily obſerved, that I endeavour throughout, not to account for things; but only to deſcribe them. I undertake barely to ſet down what appears in nature; not the cauſe of thoſe appearances. The facts lie within the reach of our ſenſes and underſtanding; the cauſes are more remote. That things are ſo, we know with certainty: but why they are ſo, we know not. In many caſes we cannot know; and the more we inquire, the more we are perplexed and entangled. God hath ſo done his works, that we may admire and adore: but we cannot ſearch them out to perfection.

6. And does not this open to us another proſpect? although one we do not care to dwell upon. Does not the ſame ſurvey of the creation, which ſhews us the wiſdom of God, ſhew the aſtoniſhing ignorance, and ſhort-ſightedneſs of man? For when we have finiſhed our ſurvey, what do we know? How inconceivably little! Is not every thinking man conſtrained to cry out, And is this all? Do all the boaſted diſcoveries of ſo enlightened an age, amount to no more than this? Vain man would be wiſe! But with how little ſucceſs does he attempt it? How ſmall a part do we know

even

even of the things that encompaſs us on every ſide? I mean as to the very fact: for as to the reaſons of almoſt every thing which we ſee, hear, or feel, after all our reſearches and diſquiſitions, they are hid in impenetrable darkneſs.

7. I truſt therefore the following ſheets may, in ſome degree, anſwer both theſe important purpoſes. It may be a means, on the one hand, of humbling the pride of man, by ſhewing that he is ſurrounded on every ſide, with things which he can no more account for, than for immenſity or eternity: and it may ſerve on the other, to diſplay the amazing power, wiſdom, and goodneſs of the great Creator; to warm our hearts, and to fill our mouths with wonder, love and praiſe!

JOHN WESLEY.

March 25, 1775.

1. I HAD finiſhed the additions which I deſigned to make to the Syſtem of Natural Philoſophy, before I ſaw Dr. Goldſmith's "Hiſtory of the Earth and Animated Nature." I had not read over the firſt volume of this, when I almoſt repented of having wrote any thing on the head. It ſeemed to me, that had he publiſhed this but a few years ſooner, my deſign would have been quite ſuperſeded: ſince the ſubject had fallen into the hands of one, who had both greater abilities, and more leiſure for the work. It cannot be denied, that he is a fine writer. He was a perſon of ſtrong judgment, of a lively imagination, and a maſter of language; both of the beauty and ſtrength of the Engliſh tongue.

2. Yet

2. Yet I could not altogether approve of this, that it ſeemed the deſign of the Author, to ſay all he could upon every article; rather than all he ſhould ſay. Hence aroſe his numerous and large digreſſions, making no inconſiderable part of his work. Hence his minute deſcription of cows, horſes, dogs; of cocks, hens, and pigeons, and of abundance of animals equally known to every man, woman and child: deſcriptions that are of little or no uſe, and no more entertaining than uſeful: at leaſt uſeful only to the Bookſeller, by ſwelling the bulk, and conſequently the price of his book.

3. Indeed this, the price of it, muſt ever remain a weighty objection to many readers. They cannot afford to purchaſe eight volumes, at ſix or ſeven ſhillings a volume. Ten or fifteen ſhillings they may poſſibly afford, for five or ſix ſmaller volumes; eſpecially when they contain all that is curious, or uſeful, in the far more coſtly work. Nay, I hope, conſiderably more than all; as I have conſulted abundance of Authors, and taken abundance of paſſages from them, whom, I apprehend, the Doctor had not ſeen.

4. I have another objection to this ingenious book: I doubt, ſome parts of it are not true. The Author indeed has corrected many vulgar errors; but has, I fear, adopted others in their place. Many times he expoſes the credulity of other writers: but does he not ſometimes fall under the ſame imputation? As where he terms preſumption, to deny the exiſtence of Biſhop Pontopedan's Cracken, and the Sea-ſerpent: the one a mile acroſs, the other raiſing himſelf out of the water, higher than the main maſt of a man of war! Could one who made the leaſt ſcruple of rejecting theſe groſs abſurdities, accuſe other writers of credulity?

5. Mean

5. Mean time the accounts which he has given of many animals, being taken from the beſt, and lateſt authorities, are both more accurate, and more to be depended on, than any which had been publiſhed before. Many of theſe I have inſerted in their places; (only contracting thirty or forty pages into four or five) often in the room of thoſe, which were leſs accurate, and probably, leſs authentic: as alſo ſeveral of his beautiful remarks, ſuch as directly tended to illuſtrate that great truth, "O Lord, how manifold are thy works! In wiſdom haſt thou made them all!"

A COM-

A

COMPENDIUM

OF

NATURAL PHILOSOPHY.

THE INTRODUCTION.

Of the gradual Improvement of Natural Philosophy.

1. *The Order observed in this Treatise.*
2. *The Method of philosophizing among the* Hebrews *and* Egyptians.
3. — *Among the* Greeks.—*The Philosophy of* Pythagoras, Plato, Aristotle.
4. *The different Methods pursued by the four* Greek *Sects.*
5. *The Philosophy of the* Schoolmen.
6. *The Revival of Philosophy by Lord* Bacon.
7. — *Greatly promoted by Philosophical Societies.*
8. *The Improvement made in every Branch of it: in* Anatomy; *the Discovery of the Circulation of the Blood; of the Lacteal Veins; and the Thoracic Duct.*
9. *Of the Generation of all Animals from Eggs.*
10. *Of the Transfusion of Blood.*
11. *Diseases themselves, and the Operations of Medicines, give Occasion for farther Discoveries.*
12. *Many Anatomical Discoveries have been made by* Microscopes:

13. *Many*

13. *Many, with regard to Brutes, particularly Fiſhes and Inſects:*
14. *Many likewiſe, with regard to Plants, Stones, Metals, and Minerals.*
15. *Great Improvements from the Art of* Chymiſtry.
16. *Diſcoveries concerning the Loadſtone:*
17. *Concerning Glaſs and Burning-glaſſes.*
18. *The Nature of the Air is more accurately diſcovered by Means of the Barometer, the Thermometer, and the Air-Pump.*
19. *Diſcoveries relating to Water.*
20. *Diſcoveries which ſhew the Nature of Fire, Gunpowder, Aurum Fulminans, Phoſphorus.*
21. *Of the Earth, and the chief Syſtems of the Univerſe.*
22. *Of the Sun, the Planets and their Satellites.*
23. *Of the Cauſes of Natural Bodies.*
24. *Of Spirits and Divine Things.*

1. NATURAL PHILOSOPHY treats both of God himſelf, and of his creatures, viſible and inviſible. Of theſe I purpoſe to ſpeak in ſuch a manner, as to aſcend from the conſideration of man, through all the orders of things, as they are farther and farther removed from us, to God the centre of all knowledge. (I mean, of viſible things:—of the inviſible world we cannot know much, while we dwell in houſes of clay.) Thus ſpeculative philoſophy aſcends from man to God: practical, deſcends from God to man.

2. The moſt ancient nations, the Egyptians and Hebrews in particular, philoſophized much concerning God, and concerning Genii, good or evil ſpirits, of an order ſuperior to man. What they taught concerning the viſible world, related chiefly to its origin, the changes it was to undergo, and its final diſſolution. But on all theſe heads they only delivered to their poſterity, what they had received from their forefathers.

3. Among the Greeks, Thales Mileſius and his followers, applied themſelves, with great induſtry, to diſcover, with the beſt helps they had, the material cauſes of natural things. They were ſucceeded by others, who more curiouſly ſearched into the ſtructure of natural bodies. Here the foundation of natural hiſtory

hiſtory was laid, in various obſervations on plants, animals, and other things. And herein the endeavours of Ariſtotle, and Theophraſtus in particular, are to be commended. Yet in other reſpects, Ariſtotle did not promote, but rather obſtruct the knowledge of nature: for he made philoſophy as unintelligible, by his abſtract and metaphyſical notions, as Plato, Pythagoras and others did, by their ideas, numbers and ſymbols.

4. In ſucceeding times, when the four Greek ſects, the Platonic, Peripatetic, Epicurean and Stoic divided the Weſtern world between them, the Platoniſts almoſt confined themſelves and their opinions to the ſubject of divinity; the Peripatetics regarded little but logic; the Stoics little but moral philoſophy; and the Epicureans had ſmall concern about any, being immerſed in ſenſual pleaſures: ſo that none of them made any conſiderable improvement in any branch of natural philoſophy.

5. When the utter barbariſm which followed, was a little diſpelled, Ariſtotle began to reign. His followers (the School-men, as they were called) might have improved natural philoſophy, if (like their maſter) they had diligently cultivated the knowledge of nature, and ſearched out the properties of particular things. But it was their misfortune, to neglect what was commendable in him, and to follow only what was blame-worthy; ſo as to obſcure and pollute all philoſophy, with abſtract, idle, vain ſpeculations. Yet ſome of them, after the Arabians had introduced the knowledge of chymiſtry into Europe, were wiſe above the age they lived in, and penetrated ſo far into the ſecret receſſes of nature, as ſcarce to eſcape the ſuſpicion of magic. Such were Roger Bacon and Albertus Magnus.

6. After the revival of learning, as all other branches of philoſophy, ſo this in particular received new light. And none was more ſerviceable herein than Lord Bacon: who, well underſtanding the defects of the ſchool-philoſophy, incited all lovers of natural philoſophy to a diligent ſearch into natural hiſtory. And he himſelf led them the way, by many experiments and obſervations.

7. After

7. After this, not ſingle perſons only, but whole ſocieties applied themſelves carefully to make experiments; that having accurately obſerved the ſtructure and properties of each body, they might the more ſafely judge of its nature. And the advantages, which have ariſen from hence, manifeſtly appear from the memoirs of the Royal Society at London; of the Academy of Sciences at Paris; and thoſe of the ſame kind in Germany, as well as ſeveral other parts of Europe.

8. To mention but a few of the late diſcoveries in each branch of natural philoſophy. With regard to the ſtructure of a human body, how many things have modern anatomiſts diſcovered, which were either little underſtood by the ancients, or wholly unknown to them? Such, for inſtance, is the circulation of the blood, diſcovered by Dr. William Harvey, whoſe "Anatomic Exercitations," concerning it were firſt publiſhed in the year 1628. Such were the Lacteal Veins, diſcovered firſt in brutes by Caſper Aſellius, of Cremona; and ſoon after in men. Such the Thoracic Duct, and receptacle of the chyle, obſerved firſt by Dr. John Pecquet, of Paris, whereby the whole courſe of the blood is now clearly underſtood.

9. Dr. Harvey improved natural philoſophy, by another no leſs eminent diſcovery: for he was the firſt of the moderns that ſhewed all animals to be generated from eggs. That the ancients knew and taught this, (Orpheus in particular) cannot reaſonably be doubted. But as the knowledge of it was entirely loſt, to revive was the ſame thing as to invent it. It is obvious, how great a light this pours upon that dark ſubject, with regard to the generation of men, as well as of other animals.

10. Another remarkable diſcovery in the laſt century, was that of the Tranſfuſion of the Blood. The blood of a young, lively, healthy animal was tranſfuſed, by means of a ſmall, ſilver tube, properly adjuſted into the veins of another, which was old, weak, and ſickly. And the effect amazed all the beholders. When the experiment was tried before ſeveral of the Royal Society, a feeble, worn-out dog, ready to die with age, and hardly able to trail his legs after him,

was

was no ſooner filled with young blood, than he leaped up as from ſleep, ſhook himſelf, and ran up and down, as lively and active as a puppy. In France the experiment has been made upon men, and with as ſurpriſing ſucceſs. What pity, that ſo important an experiment ſhould ever fall into diſuſe! That it is not ſtill repeated upon proper occaſions! Eſpecially where all other means fail.

11. It cannot be denied, that phyſicians have ſignally improved this branch of philoſophy, as they have continual opportunities of making new diſcoveries in the human body. In diſeaſes themſelves, the wonderful wiſdom of the Author of Nature appears: and by means of them many hidden receſſes of the human frame are unexpectedly diſcovered. The powers of medicines alſo variouſly exerting themſelves, lay open many ſecrets of nature.

12. And how many things in all bodies, as well as in the human, which eluded all the art and induſtry of the ancients, have the moderns diſcovered by the help of microſcopes? Although theſe are not properly a modern invention: it being certain, ſomething of this kind was in uſe many hundred years ago. There are ſeveral works of great antiquity ſtill extant; the beauties of which cannot even be diſcerned, much leſs could they have been wrought, by the fineſt naked eye which ever was in the world. Such is that ſeal, now in the cabinet of the king of France, allowed to be at leaſt fifteen hundred years old, ſix-tenths of an inch long, and four broad, which to the naked eye preſents only a confuſed groupe, but ſurveyed with a microſcope, diſtinctly exhibits trees, a river, a boat, and ſixteen or ſeventeen perſons.

13. Now whatever aſſiſts us in ſearching out the ſtructure of a human body, equally helps us to find out the nature and properties of other animals. Hence in theſe likewiſe we have received great light, from anatomical and microſcopical obſervations. Thoſe eſpecially who have beſtowed their whole time and thoughts on one kind of animals, (as Dr. Willoughby, on fiſhes, Dr. Swammerdam, of Amſterdam, on inſects) have illuſtrated to a ſurpriſing degree, the ſubjects on which they wrote.

14. Many

14. Many have diligently ſearched into the nature of plants; particularly Mr. Ray, who has not only ranged them in a new method, but alſo wrote an elaborate hiſtory of them. Others have deſcribed, with equal diligence, either plants in general, or thoſe of a particular country. And others have ſhewn the like induſtry in finding out and explaining the nature of ſtones, metals, minerals, and other foſſils.

15. Nor is it ſtrange that the moderns have penetrated farther into the receſſes of nature than the ancients, conſidering the advantages they have received, from the art of chymiſtry. Not that this is an invention of later ages: it was in ſome meaſure known long ago. But as this art has been cultivated in our age, with far greater accuracy than ever, ſo by this means many properties of natural bodies have been diſcovered; of foſſils in particular.

16. But none of theſe have ſo much engaged the ſtudy of the learned, or ſo well deſerved it, as the load-ſtone. Its attractive force was known to the ancients, and the origin of that diſcovery is recorded by Pliny. But it does not appear that they knew of its pointing to the pole, or of the uſe of the compaſs. This [the compaſs] was invented by John Goia, in the year 1300. But it has ſince been obſerved, that the magnetic needle ſeldom points exactly to the pole; but varies from it ſome degrees to the Eaſt or Weſt, in a fixt and regular order.

17. Nearly related to the nature of foſſils is glaſs, which was well known to the ancients, being mentioned by Plutarch and Lucian among the Greeks, by Lucretius, Pliny, and others among the Latins. Yet the art of making glaſs has been ſince their times abundantly improved. One branch of this is, the art of making burning-glaſſes, which are now brought to ſo great perfection, as either to melt or reduce to aſhes the moſt ſolid bodies, in a few moments. If theſe were known to the ancients at all, (which may reaſonably be doubted) yet the art was wholly loſt for many ages, and not recovered till of late years.

18. Later ages have likewiſe made many diſcoveries with regard to earth, water, fire and air: the laſt of which, air, though it be of ſo fine a texture as to

be

be wholly inviſible, yet producing ſuch amazing effects, has excited the moſt diligent inquiries of the curious. Nor does any part of philoſophy afford a wider field for experiments and diſcoveries. The weight of it we can aſcertain by that curious inſtrument, the barometer, invented by Torricellius; the degrees of heat and cold, by the thermometer. By the air-pump (invented by Otto Guerick, Mayor of Magdeburgh) the air is drawn out of any bodies, or more largely thrown into them. And hereby many effects are produced, which deſerve our diligent conſideration.

19. With regard to water, the diſcoveries of later times are numerous and important. Such are the diving-bell, invented by George Sinclair; the diving-machine of Alphonſo Borelli, a kind of boat, which is ſo contrived as to be navigated under-water: and the art of making ſalt-water freſh, which is now done with little expenſe, ſo far that the ſaltneſs is taken away, and it is fit for almoſt all uſes.

20. The nature and properties of fire alſo have been accurately traced in late ages: for which new occaſion was given by the invention of gunpowder, by Berthold Schwartz, in the fourteenth century. Aurum fulminans, a yet later invention, goes off with a louder exploſion than gunpowder. Other bodies there are, which do not burn, yet emit light. Such is the Bononian ſtone, which placed in the dark, diffuſes light like a burning coal. It is well known that the preparation called phoſphorus, has the ſame property.

21. Various theories of the earth have lately appeared. But they are no more than ingenious conjectures. The ſame may be ſaid of the ſyſtems of the univerſe, a few particulars excepted. The Ptolemaic ſyſtem, which ſuppoſes the earth to be the centre of the univerſe, is now deſervedly exploded: ſince Copernicus has revived that of Pythagoras, which was probably received by moſt of the ancients. Tycho Brahe's, which jumbles both together, is too complex and intricate, and contrary to that beautiful ſimplicity, conſpicuous in all the works of nature.

22. The teleſcope (invented by Galileo) has diſcovered many ſtars unknown to the ancients, together with the nature and motion of the planets, both primary

mary and ſecondary. By this alſo have been diſcovered the ſpots of the Sun, the inequality of the ſurface of the Moon, the nature of the galaxy or milky-way, and many other particulars relating to the heavens.

23. With regard to body in general, it is commonly ſuppoſed, that our age has a vaſt advantage over antiquity, by having found out new principles and new hypotheſes, whereby we can account for all the ſecrets of nature. But this will bear a diſpute. For beſide that the chief of our hypotheſes are not new, but known long ago, the learned have hitherto very little profited by all their hypotheſes. And in truth, all their diſquiſitions touching the cauſes of natural bodies, terminate in mere conjectures: one whereof is often more probable than another; but none admits of any ſolid proof.

24. What remains of natural philoſophy, is, the doctrine concerning God and ſpirits. But in the tracing of this we can neither depend upon reaſon nor experiment. Whatſoever men know or can know concerning them, muſt be drawn from the oracles of God. Here therefore we are to look for no new improvements; but to ſtand in the good old paths: to content ourſelves with what God has been pleaſed to reveal; with "the faith once delivered to the ſaints."

PART

PART THE FIRST.

OF MAN.

CHAP. I.

Of the Structure of the Human Body.

1. *The ſimilar, ſolid Parts.*
2. *A Fibre.*
3. *The Cellular Membrane.*
4. *A Bone.*
5. *A Cartilage.*
6. *A Membrane.*
7. *An Artery.*
8. *A Vein.*
9. *The Lymphatic Veſſels, and their Uſe.*
10. *A Nerve.*
11. *The Fleſh.*
12. *A Gland.*
13. *A Muſcle.*
14. *The Cuticula and Skin.*
    A Boy with a dappled Skin.
15. *The Fat.*
16. *The Panniculus carnoſus.*
17. *The diſſimilar Parts; in particular, the Head, Cerebrum, Cerebellum, Medulla oblongata.*
18. *The Meninges.*
19. *The Brain.*
20. *The Origin of the Nerves.*
21. *The Pineal Gland.*

22. *The*

22. *The Guards of the Eye.*
23. *The Muſcles of the Eye.*
    The Tunica adnata.
    The Structure of the Eye.
24. *The Coats of the Eye.*
25. *The Humours of the Eye.*
26. *Peculiarities relative to them.*
27. *Queries concerning the Eyes.*
    Help for decayed Sight.
    Account of a Perſon couched.
28. *The external Parts of the Ear.*
    The internal: particularly the Drum.
29. *The Bones, Paſſages, Windows, Labyrinth.*
30. *The Noſtrils.*
31. *The Tongue, and Teeth.*
    A Perſon ſpeaking without a Tongue.
    Perſons deaf and dumb taught to ſpeak.
    Dumbneſs ſuddenly removed.
32. *The Palate.*
33. *The Uvula and Tonſils.*
34. *The Hair.*
    Hair turned white through Fear.
    Through Grief.
    White Hairs triangular.
35. *The Heart.*
36. *The Pericardium.*
37. *The Lungs.*
38. *The Thorax, intercoſtal Muſcles.*
    Diaphragm.
39. *The Pleura and Mediaſtinum.*
40. *The external Parts of the Middle Cavity.*
    An old Woman giving Suck.
41. *The Stomach.*
42. *The Inteſtines and Meſentery.*
43. *The Lacteal Veins.*
44. *The Omentum, Peritoneum, Pancreas.*
45. *The Liver, Gall-Bladder, and Ducts.*
46. *The Spleen.*
47. *The Kidneys, Ureters, Bladder.*
48. *The Hands.*
    Account of a Man without Arms.
49. *The Feet.*
50. *The Animal Spirits.*

51. *Secretion of the other Fluids.*
52. *The Blood.*
53. *What are the firſt Elements of the Body.*
54. *Reflections.*

1. AS man ought to know himſelf beſt, we begin our treatiſe here. And firſt, let us contemplate the human body. The parts of this are either ſolid or fluid. Thoſe of the ſolid, of which the reſt are formed, are termed ſimilar parts. Such are fibres, bones, membranes, ligaments, arteries, veins, lymphatic veſſels, nerves, fleſh, muſcles, tendons: and thoſe general coverings of the body, the cuticle, the ſkin, fat, and the panniculus carnoſus.

2. A fibre is a kind of ſlender thread, of which all the other parts of the body are woven: according to the difference of which, the ſubſtance of the fibres is different alſo.

Earth, as an element, is a ſolid, opaque, angular, friable ſubſtance, of ſuch ſmall volatile particles, that it readily diffuſes itſelf through air and water, and reſides inviſibly in them. And earth eagerly imbibing both air and water, by their means forms the permanent baſis and growth of all mineral, vegetable, and animal bodies.

Theſe earthly particles have their connexion and power of coheſion, not from themſelves or a mere contact; but from the intermediate glue placed betwixt them.

That this glue is compoſed of oil, combined with water, by the vital attrition in animals, appears from the chymical analyſis of bones and hair; from the jelly of bones, ivory, and horns; and from the nature of our aliments themſelves. Nor is there any kind of glue that could more powerfully join the parts of animals as, we experience in fiſh glue, and that of joiners and cabinet-makers.

Earthy particles then cohering longitudinally, and tied together by an intervening coheſive glue, compoſe firſt one of the leaſt or moſt ſimple fibres; ſuch as we have a knowledge of rather from reaſon than ſenſe.

The

The fineſt microſcopes have been hitherto inſufficient to lead us to a ſight of the ſmalleſt moving and nervous fibrils, and ſtill leſs can we ever expect from them, to get any ſenſible idea of the mechaniſm by which ſenſation and motion are effected.

But the leaſt fibres which appear to the ſight, are of two kinds.

Of theſe two kinds of fibres, as we ſhall preſently ſee, we may diſtinguiſh the former by the title of filamentary, and the latter of membranous.

The firſt kind of theſe fibres is lineal, namely, ſuch a form as makes their length conſiderably large in proportion to their breadth; and which, by diſpoſing of the elementary particles in a right line, muſt of courſe lay them generally parallel with the neighbouring or contiguous fibres. Examples of ſuch fibres we ſee in the bones, and moſt eaſily in thoſe of a fœtus; and likewiſe in the tendons, ligaments, and muſcles; only we muſt here always remember, that the eye never reaches to the ſmalleſt fibres, but to larger ones made up of the ſmalleſt, and like to them in ſlenderneſs, placed together in a rectilineal courſe. That theſe are not different from the ſmalleſt fibres, we are perſuaded by the moſt accurate microſcopes of Muyſe and Lewenhoeck; by which the muſcular fibres divided even to the laſt, appear ſimilar to the larger, till, at length, they ſeem mere lines, like ſpiders threads.

The ſecond kind of fibres are thoſe which are conjoined with a breadth frequently larger than their length.

From what has been ſaid, we may admire nature no leſs for her wiſe œconomy than ſimplicity, in thus forming all that variety of parts we ſee in an animal, from one ſimple maſs of clay or ſlimy matter, compounded of earth and glue; from whence the body is not only augmented from a ſingle point in the ovum to its full growth and ſtature; but like the timbers of a ſhip, is alſo every day repaired during life, till at length, not two jots of the old or firſt materials remain. This renovation of parts is made ſlower in ſome conſtitutions, and in ſome organs, than in others. How quickly the animal humours, with the hair, nails,

&c.

&c. are renewed, every one knows: and we may venture to ſay, that once in three years the change is univerſal; at the end of which time, though a man remains the ſame identical perſon, he is not the ſame matter.

3. But we proceed from theſe ſimple fibres, to the next leaſt compounded ſolid which they compoſe; viz. the cellular web-like ſubſtance.

This is made up partly of the ſimple fibrils, and partly by an infinite number of little plates or ſcales, which, joined in various directions, intercept ſmall cells and web-like ſpaces; and by extending round every, even the leaſt moving ſolid parts of the body, conjoins them all together in ſuch a manner as not only ſuſtains, but allows them a free and ample motion.

The extenſion of this ſubſtance, not only with the ſkin round the whole body, but alſo round every viſcus or organ, and round every individual moving fibre or veſſel of them, into the cavities of the bones, and even the ſubſtance of the brain and its medulla, is a modern and wonderful diſcovery. This ſubſtance in its ultimate ſtate being compoſed of ſimple membranes, when compacted and convoluted, gives birth to the leaſt or moſt ſimple veſſels, which again reflected through plates of the ſame ſubſtance compacted together, make compound and vaſcular membranes; to the conſideration of which we next proceed.

Out of this cellular ſubſtance compacted by a concretion of the membranous plates or partitions, and preſſed together by the force of the incumbent muſcles, and diſtending fluids; ariſe other broad and flat plates or ſkins in various parts of the body; which being generally diſpoſed in one and the ſame direction, ſeem to have a better right to the name of membrane than the former; and theſe being convoluted into cones and cylinders, pervaded by a flux of ſome juice or liquors brought to them; put on the name of veſſels, or elſe being extended round ſome ſpace that is in a plane, parallel to itſelf, we call it a tunic or coat.

This cellular ſubſtance in the human body, is found throughout the whole; wherever any veſſel or moving muſcular fibre can be traced, and this without the leaſt exception,

exception, that I know of, in any part whatever. But ſo far as ever we can trace, it hardly ever admits of any fat into the cells; which are rather moiſtened by a watry vapour, ſomewhat oily, exhaled out of the arteries and received again into the veins.

Its plates or ſcales are ſtill more looſe and open where it divides the muſcles and all their fibres (even to the ultimate fibre;) and likewiſe where it ſurrounds and ſuſtains the leaſt veſſels with their free motion. That within the cavities of the bones is alſo made up of bony plates, with membranous ones intermixed; and laſtly, it is the moſt looſe and open of all, round the ſurface of the body on all ſides, betwixt the muſcles and the ſkin.

Through this cellular ſubſtance the ſmall veſſels are ſpread, and ramified in all parts of the body; from whoſe arterial extremities the fat is depoſited into the cells, and afterwards abſorbed by the venal orifices. This paſſage from the arteries, into the adipoſe cells, is ſo free and ſhort, that there muſt needs be very large mouths by which they open, and by which they give admittance to injected mercury, air, or water. The oily fat, in this ſubſtance, is ſeparated and expelled from the artery; not by any long ducts, but by tranſuding on all ſides through the whole extent of the veſſel. How quickly it is collected from the arteries, appears from the ſpeedy renovation of it, by a returning fatneſs after acute diſeaſes.

With regard to the ſponge-like communications of this ſubſtance, it is remarkable, the intervals or ſpaces betwixt the plates or ſcales that make up their ſides in the cellular membrane, are every where open, and form one continuous cavity throughout the whole body.

That out of this ſubſtance joined with veſſels, nerves, muſcular and tendinous fibres, (a great part of all which are before formed of this ſubſtance only) all the viſcera, all the muſcles and glands, with their ligaments and capſules, are entirely compoſed; and that only from the different length, tenſion, quantity or proportion of this, the diverſity of our glands and viſcera ariſes; and laſtly, that this alone makes up by far the greateſt part of the whole body, we are certain,

if

if the whole be not formed out of the cellular filaments of this kind.

4. The hardeſt part of the body, white and void of ſenſe, is termed a bone. The bones are covered with a thin ſkin, called the perioſteum, extremely ſenſible.

The bones conſiſt of thin plates, lying one upon another; and theſe again, of fibres running lengthways; ſome to the extremity of the bone, ſome not ſo far. Yet none of them terminate there; but are continued tranſverſely, and as it were arched, the fibres of one ſide meeting and uniting with thoſe of the other, and this at each extremity.

Theſe plates are differently diſpoſed in different bones: in thoſe that have a large cavity, they are contiguous on each ſide, and very cloſely united. In thoſe whoſe cavities are ſmall, many of the inner plates are diſtant from each other; having little long cells between them. In bones whoſe plates are contiguous, there are pores through and between them, (beſide thoſe for the blood-veſſels.) The firſt pierce them tranſverſely, from the cavity to the external ſurface of each plate. The ſecond run lengthways between the plates, and diffuſe an oil with which they are ſupplied by the tranſverſe pores.

The bones are generally bigger at each end than in the middle, that the joints may be firm, and the bones not ſo eaſily diſlocated. But to ſtrengthen the middle of the bone, the fibres there are more cloſely compacted. Likewiſe the bone, being large and hollow, is not ſo eaſily broke, as if it had been ſolid and ſmaller; for of two bones of equal length and equal number of fibres, that is ſtronger which has the larger diameter.

The blood-veſſels uſually enter the ends of the bones; the arteries at one end, the veins at the other. The medullary veſſels commonly enter the ſides of the bone, and that obliquely.

The marrow is covered with a membrane, wherein are incloſed little bags. In theſe bags are glandulous bladders, ſerving both to ſecern the marrow from the blood, and to receive it. Both theſe and the bags have paſſages into each other, whereby the marrow has free courſe.

courſe. It paſſes firſt through the tranſverſe pores of the firſt internal plate into the longitudinal ones. Thence it proceeds into other tranſverſe pores, when it alters its courſe again, and exſudes farther. Thus it paſſes alternately through and between the plates, till it is diffuſed throughout. In this manner it is diffuſed through bones, whoſe plates are contiguous. But where the plates are at a diſtance, the ſmall cells contain glands, which directly ſupply the plates with marrow.

The marrow not only ſerves to keep the ſubſtance of the bone moiſt, but to lubricate the joints, and to hinder the ends of the bone, from being worn or overheated with motion. It alſo moiſtens the ligaments, which tie them to each other: as do likewiſe the glands found in all the joints. The back-bone hath theſe two things peculiarly remarkable. 1. Its different articulations from the other joints of the body. For here moſt of the joints are flat, and withal guarded with aſperities and hollows, made for catching and holding; ſo as firmly to lock and keep the joints from luxations, but withal to afford them ſuch a motion, as is neceſſary for the incurvations of the body. 2. The difference of its own joints in the neck, back and loins. In the neck the two upper vertebræ, are curiouſly made, and jointed (different from the reſt) for the commodious and eaſy bending and turning the head every way. In the thorax, and back, the joints are more cloſe and firm; and in the loins more lax and pliant; alſo the knobs and ſockets are turned a quite contrary way, to anſwer the occaſions the body hath to bend more there, than higher in the back. So that its ſtructure is the very beſt that can be contrived; for had it been all bone, we could have had no motion in our body; had it been two or three bones articulated for motion, the medulla ſpinalis muſt have been neceſſarily bruiſed at every angle or joint; beſides, the whole would not have been ſo pliable, for the ſeveral poſtures we have occaſion to put ourſelves in. If it had been made of ſeveral bones without intervening cartilages, we ſhould have had no more uſe of it, than if it had been but one bone. If each vertebra had had its own diſtinct cartilage, it might have been eaſily

diſlocated.

diſlocated. And laſtly, the oblique proceſſes of each ſuperior and inferior vertebra, keep the middle one, that it can neither be thruſt backwards nor forwards to compreſs the medulla ſpinalis.

The pelvis made in the belly by the ilium, oſſa coxendicis, and pubis, is larger in a female than in a male ſkeleton, that there may be more room for the laying of the viſcera and fœtus. So the cartilage bracing together the two ſharebones, is twice thicker and laxer in women than men. As alſo is the cartilage that ties the os ſacrum to its vertebra; and all, to give way to the paſſage of the fœtus.

Another conſiderable difference is, in the cartilaginous production of the ſeven long ribs, whereby they are braced to the breaſt-bone. Theſe are harder and firmer in women than in men; the better to ſupport the weight of the breaſts, the ſucking infants, &c.

It is remarkable in the joints, and a manifeſt act of caution and deſign, 1. That although the motion of the limbs be circular; yet the centre of that motion is not in a point, but an ample ſuperficies. In a point, the bones would wear and penetrate one another, and the joints would be exceeding weak. But the joint conſiſting of two large ſuperficies, concave and convex, ſome furrowed and ridged, ſome like a ball and ſocket, and all lubricated with an oily ſubſtance; they are incomparably prepared both for motion and ſtrength. 2. That the bones next the joints are not ſpungy, as their extremities commonly are, nor hard and brittle; but capped with a ſtrong, tough, ſmooth, cartilaginous ſubſtance, ſerving both for ſtrength and motion.

For affording this oily matter there are glandules very commodiouſly placed near the joints, ſo as not to ſuffer too great compreſſion by the motion of the neighbouring bones, and yet to receive a due preſſure, to cauſe a ſufficient emiſſion of the oil into the joints. Another thing conſiderable is, that the excretory ducts of the mucilaginous glands have ſome length in their paſſage from the glands to their mouths; which is a good contrivance, to prevent their mouth being oppreſſed by the mucilage, and alſo to hinder the too plentiful effuſion thereof, but yet to afford a due expreſſure of it at all times, and on all occaſions; par-

ticularly in violent and long-continued motions of the joints, when there is a greater than ordinary expense of it.

That the nouriſhment taken in, is continually conveyed through the bones, as well as the fleſh, appears from an eaſy experiment. Mix red liquor with the food of any animals, and in a ſhort time, their bones are died red. When madder root was mixed with the food of a cock, which died after ſixteen days, all his bones were red, the internal parts as well as the external. And the moſt ſolid parts were the moſt deeply tinctured: in ſwine, the teeth above all the reſt.

5. Annext to the bones are the cartilages, white, flexible and ſmooth; moſt of which in proceſs of time become bones, hard and quite void of ſenſe.

A cartilage is an elaſtic ſubſtance, uniformly compact and ſomewhat tranſparent, harder and more brittle than a ligament, ſofter than a bone. It is covered with a fine membrane, folded over the bone, from where the ligament is inſerted. Every joint is inſerted with a membrane, which forms a complete bag, and covers every thing within the articulation. The blood-veſſels are ſo ſmall, that they do not admit the red globules, and are demonſtrable only in very young ſubjects. All round the neck of the bone, there are numerous arteries and veins which ſpread into ſmaller branches, and communicate with each other. Theſe divide into ſtill ſmaller branches on the adjoining ſurface, as they run toward the centre of the cartilage. We can ſeldom trace them into its ſubſtance, becauſe they end abruptly, at the edge of the cartilage. The larger veſſels, plunge in by numberleſs ſmall holes, and diſperſe themſelves into branches between the cartilage and bone. From theſe again there ariſe many ſhort, but ſmall twigs, which ſhoot toward the outward ſurface. This diſtribution of the blood-veſſels is very peculiar, and calculated for obviating great inconveniencies. Had they run on the outward ſurface, the preſſure and motion of the two cartilages muſt have occaſioned frequent obſtructions and inflammations. But by creeping round the cartilaginous brim, where there is little friction, or under the cartilage, where there is none,

none, they are perfectly well defended from all ſuch accidents.

Cartilages are admirably contrived for all the purpoſes of motion. By their uniform ſurface they move one upon another with eaſe: by their ſoft, ſmooth and ſlippery ſurface, mutual abraſion is prevented. By their flexibility, the contiguous ſurfaces are conſtantly adapted to each other. By their elaſticity the violence of any ſhock, which might happen in running, jumping, or the like, is broken, which muſt have been extremely pernicious, if the hard ſurfaces of bones had been immediately contiguous. The cartilaginous fibres appear calculated chiefly for this laſt advantage. To conclude, the inſenſibility of theſe cartilages is ſo wiſely deſigned, that by this means the neceſſary motions of the body may be performed without pain.

6. The various parts of the body are clothed with membranes, which are whitiſh tunicles, extremely thin and flexible, compoſed of fibres interwoven with each other, as a piece of cloth is of threads. They are faſtened together by a kind of cartilages, which are termed ligaments.

7. An artery is a hollow canal, compoſed of fibres cloſely twiſted together, which conveys the blood from the cavity of the heart to all the parts of the body. All the arteries ſpring from two, the aorta or great artery, and the pulmonary artery. The latter conveys the blood from the right ventricle of the heart, through the lungs, into the left ventricle. The former conveys it from the left, to all other parts of the body.

The arteries ordinarily conſiſt of three coats or membranes. The outermoſt has been generally thought to be compoſed of fine blood-veſſels. The ſecond is muſcular, and made of firm and ſtrong circular, or rather ſpiral fibres: of which there are more or fewer ſtrata, as the artery is larger or ſmaller. Theſe fibres are extremely elaſtic. The inmoſt coat is a fine denſe, tranſparent membrane, containing the blood, which otherwiſe would eaſily ooze through the ſpiral fibre.

On a more accurate examination it has been found, that the outermoſt coat of all arteries is a cellular ſub-

ſtance, compoſed of fine, pellucid membranes, which may be ſtretched, even ſuddenly to a great extent without breaking. And they as ſuddenly collapſe, when that ſtretching force is removed. Theſe cells contain an oily liquor which their coats ſecern from the branches of the artery that are ſpread over them. This cellular ſubſtance of the arteries ſerves to connect them with the ſurrounding part, without hindering their actions or motions. It gives a ſafe paſſage to the veſſels of their other coats, and ſupplies oil for lubricating them. There is alſo another cellular ſubſtance, between the membranes and the muſcular coat.

All the arteries begin with a larger trunk, and grow leſs and leſs till they are no longer ſeen by the naked eye. Hence they are continued, till they inoſculate with the veins, and ſo form one uninterrupted channel.

They appear white, becauſe their coats are of ſo denſe a contexture, that the blood is not viſible through them. This proceeding from wider to narrower canals, is continually obſtructed in its paſſage. But being puſhed on from behind, it diſtends the coats, and cauſes that leaping motion called the pulſe. By this, as well as by their whiteneſs, arteries are diſtinguiſhed from veins.

The pulſe of a healthy perſon, riſing in the morning, beats 65 in a minute; but after the fatigue of the day, it will in the evening beat eighty in that time; and again, by the night's reſt or ſleep, it will become leſs frequent till in the morning, you will find it return to ſixty-five. For the voluntary motions of the muſcles, and actions of the external and internal ſenſes, urge the venal blood on to the heart, which, being thereby oftner ſtimulated, makes more frequent contractions. This is the cauſe of thoſe paroxyſms or fits of increaſe, obſervable in all fevers towards the evening. For ſleep not only retards the motion of the blood, but of all the other humours and actions in the body.

It is one of the curious obſervations of Dr. Hales, that the pulſe is quicker in ſmall animals. He found the pulſe of a horſe ſlower by half than in a man, viz. 32 only in a minute; whereas in a dog, the pulſe beat 97 in that time. And this we ſee is conformable to the blood's heat, meaſured by the mercurial thermometer

meter of Farenheit's ſcale. For the blood in oxen, horſes, and other large animals at reſt, being five or ſix degrees cooler than in us, will not riſe to our heat, but by labour; whereas, dogs, cats, and fowls, are five or ſix degrees hotter than we, (viz. about 102;) and the latter, when ſitting or brooding on their eggs for young, are ſtill four or five degrees hotter, viz. 107 or 108, which is commonly the heat of our blood in the fit of an ague; where it is obſervable, that during the greateſt ſenſe of cold chill, the blood is three or four degrees hotter than in health, after which it gains four or five degrees more in the height of the hot fit, viz. 104 or 105 degrees; but in ardent fevers, where the pulſe beats 140, the heat of blood will ſtill be four or five degrees higher, viz. 110; i. e. two or three degrees more than equal to a brooding hen.

The pulſe is more quick in children, and becomes ſlower in perſons as they grow older. The ſalient point of an ovum beats a 134 in a minute. New born infants have their pulſe 120, and from thence down to old age it grows ſlower, to 60 in a minute. A feverish pulſe begins at 96 per minute; it is exceſſive at 130 or 140, which is the number of the pulſe with which a perſon dies. The pulſe beats ſlower in winter, and quicker in ſummer, by about ten ſtrokes per minute; and under the torrid zone, it grows quicker to 120.

8. A vein is a hollow canal, which receives the blood from the artery, and conveys it back to the heart. The chief veins are three, the vena cava, which pours the blood through a wide paſſage into the right ventricle of the heart; the pulmonary vein, which in like manner pours it into the left ventricle; and the vena portæ, which does not, like the two former, end in a large trunk; but ſpreads itſelf at each extremity into numerous branches.

In the cavity of the veins, there are certain thin tunicles, which are termed valves. Theſe, during the regular motion of the blood, lie cloſe to the ſide of the inner coat: but in caſe of any obſtruction, recede from it and cloſe the paſſage, to prevent the blood's falling back.

9. The

9. The lymphatic veſſels are ſmall canals full of valves, conſiſting of a thin, tranſparent tunic, which convey an extremely clear liquid into the maſs of blood. Probably theſe (as well as the veins) and all the other veſſels, are only continuations of the arteries.

It has been lately diſcovered, that the lymphatic veſſels have two coats; betwixt which there are innumerable fine filaments, containing a nutricious juice, which is conveyed into all parts of the body, by a motion from the centre to the circumference, and returns through the inner pipes, of the ſame watry veſſels. But this juice when returning, is no more water or dew, but ferment; and the veſſels may be termed ferment-veſſels. This ferment is conveyed into the blood, by a motion from the circumference to the centre.

The lymphatics carry their dewy particles through the glandules, which lie between the two coats. In the lowermoſt end of theſe glandules, the ferment-veſſels take their riſe. Moſt of the juice of the lymphatic veſſels is diſcharged between the coats of the veins, arteries, and veſſels, in the meſentery; to be conveyed into all parts of the body, both internal and external. Even in bearing females, the fruit is not nouriſhed by blood, but by this nutricious juice: the remaining part of which, is tranſmitted into the blood through the thoracic duct and jugular veins.

10. A nerve is a whitiſh, round, ſlender body, ariſing from the brain, which is ſuppoſed to convey the animal ſpirits to all parts of the body. What theſe ſpirits are none can ſhew: nay we are not ſure they have any being. For none can certainly tell, whether the nerves are hollow canals, or only ſolid threads, encloſed in proper integuments.

11. The fibrous, ſoft, reddiſh part of the body is termed fleſh. All fleſhy fibres are hollow, and divided through their whole length into little caverns, wherein the blood is detained, as occaſion requires.

12. A gland is a ſoft and ſpungy body, which ſeparates ſome particular liquid from the blood. The

larger

larger glands contain arteries, veins, and lymphatic veſſels: but the glands of the inteſtines are only the tops of the arteries.

There is a kind of down in the cavity of every gland, which probably does the office of a filter, and is that whereby a particular humour is ſeparated from the blood.

The ſtructure of the down-veſſel is different according to the different purpoſes of nature. Sometimes the liquor filtrated through it, falls drop by drop on a membrane, to which one end of the veſſel is faſtened, as where it is deſigned only to moiſten the part. Sometimes many of theſe down-veſſels ſpread over the inner ſurface of a membranous cell, into which they all pour their liquor, which is diſcharged at a ſmall orifice.

Theſe veſſels are often of a great length, though they take up but little room, being wound over one another, ſometimes in a ſingle knot, and ſometimes in ſeveral, encloſed in a common membrane. And hence is the diſtinction of glands into conglobate and conglomerate.

A conglobate gland is a little, ſmooth body, wrapt up in a fine, double ſkin; with only an artery and nerve paſſing in, and a vein and excretory duct going out.

A conglomerate gland is an irregular aſſemblage of ſeveral ſimple glands, which are tied together and wrapt up under one common membrane.

13. A muſcle is a bundle of fibres joined and faſtened together, with their proper veins, arteries and nerves. It is divided into little cells by tranſverſe fibres, parallel to each one, whereby it may be contracted and ſhortened, or relaxed and lengthened again. Its extreme parts are more cloſely compacted, which we term tendons. By theſe the muſcles are connected with the neighbouring parts. A muſcle generally conſiſts of three parts: the upper, termed the head, the middle, termed the belly, and the lower part, or tail.

Every muſcle is diviſible into ſmaller muſcles, and thoſe into other ſtill ſmaller: and ſo on, beyond all imagination. The laſt and ſmalleſt parts are muſcular

fibres.

fibres. But there is no aſſignable point in any muſcle, wherein there is not ſome nerve. And here all the nerves diſappear; (in other parts their extremities expand into membranes.) It is therefore probable that the muſcular fibres, are only the nervous continued.

14. The cuticle, or ſcarf-ſkin, is an extremely thin and tranſparent membrane, void of ſenſe, and covering the ſkin all over, ſticking faſt to its ſurface, to which it is alſo tied by the veſſels that feed it. It conſiſts of ſeveral layers of exceeding ſmall ſcales, which cover one another where it is thick. But in the lips, where it is extremely thin, they little more than touch one another.

In ſome creatures, (as fiſhes) theſe ſcales are only the excretory ducts of the glands of the ſkin. In others, thoſe glands have their proper ducts, opening between the ſcales.

It is ſuppoſed, there are in one ſcale 500 excretory ducts, and that a grain of ſand will cover 250 ſcales. If ſo, a grain of ſand will cover 125,000 of our pores.

The cuticle ſerves to defend the nerves of the ſkin, both from the air, which would dry and make them leſs ſenſible, and from rough and hard bodies, which would make a painful impreſſion on the naked nerves.

Negroes have a ſkin between the cuticle and the true ſkin. They are born white; but the middle ſkin, in a little time, turns black, and gives that colour to the whole body.

But who can account for the following caſe? Sir Charles Wager had a boy about eleven years old, who was born in Virginia, of negro parents. Till he was three years old, he was like other black children. He then, without any diſtemper, began to have little white ſpecks upon his neck and breaſt. Theſe increaſed with his years, both in number and bigneſs, ſo that from the upper part of his neck, quite down to his knees, he was dappled with white ſpots, ſome of them broader than the palm of a man's hand. They were wonderfully white, equal to the ſkin of the faireſt lady, only ſomewhat paler. His face, arms and legs, were perfectly

fectly black. He was exceeding active, ſprightly, and more ingenious, than is common among that generation.

Perhaps the following fact is no leſs difficult to be accounted for. A Negro woman, cook to Colonel Barnes, in Maryland, about forty years of age, remarkably healthy, had her ſkin as dark as that of the moſt ſwarthy African. But that part of it next her finger nails, about fifteen years ago became white. Her mouth ſoon underwent the ſame change, which has ſince gradually extended over the whole body. At preſent, four parts in five of her ſkin, are white, ſmooth, and tranſparent, as in a fair European, elegantly ſhewing the ramifications of the ſub-jacent blood-veſſels. The other parts daily loſe their blackneſs, and partake of the prevailing colour. The neck and back retain moſt of their priſtine hue; the head, face, breaſt, legs and arms are all white. Her face and breaſt, when anger or ſhame has been excited in her, have been immediately obſerved to glow with bluſhes. This is the naked fact; but upon what principles of philoſophy can we account for it?

The ſkin covers almoſt the whole body, and is formed of whitiſh fibres, intermixt with numberleſs branches of nerves, veins and arteries. On its ſurface are many furrows, or indented lines, having generally hairs on each ſide, and pores, or little holes of various ſizes, ſerving for the tranſpiration of ſuperfluous particles. Under the ſkin lie the ſubcutaneous glands, which are ſuppoſed to tranſmit through the pores an inſenſible ſteam, commonly believed to be of the ſame kind with what, when ſenſibly thrown out, is called ſweat.

The pores in our hands and feet are very remarkable. Survey with a glaſs the palm of your hand, well waſhed, and you may perceive innumerable little ridges, of equal bigneſs and diſtance, every where running parallel with each other: theſe are very obſervable on the ends and firſt joints of the fingers and thumb, and near its root, a little above the wriſt.

On theſe ridges ſtand the pores, all in even rows. Through a good glaſs every pore looks like a fountain. The ſweat may be ſeen to ſtand therein, as clear

as rock water. The ridges are ſo placed, that they may better ſuit with the uſe and motion of the hand: thoſe on the lower ſide of each triangle, to the bending in of the fingers: thoſe on the other two ſides, and on the elliptic ridges, to the preſſure of the hand or fingers ends againſt any body, requiring them to yield to the right and left.

The pores are placed on theſe ridges, not in the furrows between them, that their ſtructure may be leſs liable to be injured by compreſſion, whereby the furrows only are dilated or contracted: the ridges conſtantly maintaining themſelves; and ſo the pores are unaltered. For the ſame reaſon the pores are very large, that they may be the better preſerved; though the ſkin be never ſo much compreſſed and condenſed, by the conſtant labour of the hand: and ſo thoſe on the feet, that they may be preſerved, notwithſtanding the compreſſion of the ſkin, by the weight of the whole body.

Through the pores there continually tranſudes a ſubtle vapour from every point of the body, being what redounds of the aliment, comminuted to the higheſt degree, and ſent to repair every particle of it. And the matter thus evacuated is more than is thrown out by all the other paſſages together.

A perſon of middle age found what he perſpired was five eighths of the food taken in: ſo that there remained only three eighths for nouriſhment and all other evacuations. He obſerved alſo that ſo much is perſpired in one day, as paſſes by ſtool in fourteen: and more particularly, that in a night's time about ſixteen ounces are uſually thrown out by urine; four by ſtool, and about forty by inſenſible perſpiration.

If a man eats and drinks eight pounds in a day, five pounds of it paſs by perſpiration; namely about one pound within five hours after eating; (perſpiration being leaſt of all ſoon after eating) from the fifth to the twelfth hour, about three pounds, and from the twelfth to the ſixteenth, ſcarce half a pound. Exerciſe increaſes perſpiration much. But it is naturally leſs in women than men.

While this ſteam flows from our body, it conſtantly imbibes a ſupply of moiſture from the air, which ſerves

to

to keep all its parts ſoft, pliant and fit for motion. Hence, from the greater moiſture of the air, we perſpire leſs in winter than in ſummer, and in rainy weather than in fair. Live therefore, if poſſible, in a clean houſe, and in a pure, dry air.

This inhalation is very conſiderable. Dr. Keil found his body to have imbibed in one night eighteen ounces of moiſture. And on a ſudden change of weather from dry to wet, the inſpiration ſometimes exceeds the expiration: there being abſorbent-veins, which accompany the numberleſs arteries from which the perſpiration is diſcharged. To the matter thus imbibed (not the obſtruction of the pores) he aſcribes what we term a cold. Sweating cures this, by throwing out the noxious matter which was imbibed before.

The cutaneous veſſels both exhaling and inhaling, are capable of contraction and relaxation, by the power of the nerves. This appears from the effects of the paſſions, which if joyful, increaſe the circulation, and relax the exhaling veſſels. Thoſe paſſions on the contrary, which are ſorrowful, and retard the circulation, contract the exhaling veſſels, as appears from the dryneſs and corrugation of the ſkin, like a gooſe-ſkin after frights; and from a diarrhœa cauſed by fear. But the ſame affections ſeem to open the inhaling veſſels; whence the variolous or peſtilential contagions are eaſily contracted by fear.

The benefits of inſenſible perſpiration are ſo great, that life cannot be preſerved without it. And the ſubtilty, equability and plenty of what we perſpire, are the grand ſymptoms of health.

But how little do we know even of our own frame! It has hitherto paſſed as an unqueſtionable truth, that the ſame matter which paſſes by inſenſible perſpiration, paſſing in great quantities, is ſweat. Whereas an ingenious phyſician, Dr. Rogers, has found by numerous experiments, that a perſon perſpires abundantly leſs, when he ſweats, than when he does not: that one who perſpires twenty-four ounces in ſeven hours ſleep, if he ſweats, does not perſpire above ſix. This he tried many times, and never found it to fail. Whence he infers, 1. That it is not the ſame matter which is evacuated by inſenſible perſpiration and by ſweat. 2. That

it

it is not evacuated through the ſame pores: 3. That the ſweat-pores are abundantly larger and fewer, than thoſe which ſerve inſenſible perſpiration: 4. That ſweat greatly hinders that perſpiration, both by covering thoſe pores with a clammy liquor, and by conſtringing them ſo that they cannot open; which muſt be the caſe, when the ſweat-pores are dilated. What a field does this open!

Some queries propoſed concerning perſpiration, by an ingenious writer, ſeem to deſerve a ſerious conſideration. 1. "Why do carnivorous animals ſweat ſo little? A fox hunted almoſt to death never ſweats. 2. Why do thoſe which feed on vegetables perſpire ſo much? Horſes and cows for example. We may often ſee them involved in a cloud of their own vapours, yea, almoſt covered with froth. 3. How can animals, whoſe natural food is vegetables, be kept alive, and in health in very cold climates, by purely animal food? Cows in Iceland and Norway, are fed in winter upon fiſh-bones." I would beg leave to aſk, 4. Do the ſweat-pores only, imbibe? Or thoſe alſo, which ſerve for inſenſible perſpiration?

15. Fat, a whitiſh, oily ſubſtance, void of ſenſe, is ſecreted from the blood, and lodged in ſmall, oval, membranous bags, which ſhoot out of the arteries. It is found in various parts, but chiefly under the ſkin, where (unleſs a man be emaciated) it runs co-extended with the ſkin over moſt parts of the body.

Fat is ſecerned from the arterial blood by the adipoſe glands, and tranſmitted again from the membranous cells to the blood through the veins. It ſeems to be a portion of the blood coagulated by the nitrous air mixed with it in the lungs. Artificial fat is made, by mixing, for ſome days, oil of olives with ſpirit of nitre. Hence divers animals grow fat in froſty weather, the air then abounding with nitre.

The uſes of the fat are various; as to facilitate the motions of the muſcles in all parts, leſſen their attrition againſt each other, and prevent a ſtiffneſs or rigidity; it fills up the intermediate ſpaces between the muſcles in ſuch a manner, with the cavities about many of the viſcera, that it readily yields to their motions, and yet

ſupports

ſupports them when at reſt; it ſerves as a ſtratum or bed to conduct and defend the veſſels in their courſe to all parts; it gives an uniform extention to the ſkin, and ſerving as a cuſhion to eaſe the weight of the body in many parts, at the ſame time it renders the whole of a comely, agreeable ſhape: it probably, by returning and mixing with many of the humours, abates their acrimony; it has a principal ſhare in forming the matter of the bile, and by tranſuding through the cartilaginous incruſtations of the bones, it mixes with the articular liniment or ſynovia; alſo by exhaling in a living perſon from the meſentery, meſocolon, omentum, and round the kidnies, it lubricates the ſurfaces of the viſcera with an oily emollient vapour, and by interpoſing betwixt their integuments, prevents their growing one to another.

Yet too much fat is a real diſeaſe, which hinders the motion of the lungs, entangles the moſt active particles of the blood, and naturally creates dulneſs and heavineſs. You may cure this, by following three plain rules: eat and drink little; ſleep little; work much.

16. The fourth general integument is the panniculus carnoſus, which in ſome parts is of a fleſhy ſubſtance; in others, a mere membrane, lying juſt under the fat.

17. The diſſimilar parts are compoſed of the ſimilar. The chief of theſe is the head. The cavity of the ſkull is nearly filled with a ſoft ſubſtance, termed in general, the brain. But this is properly that part of it which lies forward. The hinder part (conſiderably ſmaller) is called the cerebellum. Under both, but chiefly the latter, and ſpringing from the internal ſubſtance of both, is the medulla oblongata.

The ſkull is divided into two plates, one laid over the other. Between theſe is a ſpongeous ſubſtance, made of bony fibres detached from each plate. Hereby the ſkull is made not only lighter, but far leſs liable to fractures.

The ſkull is covered with a membrane called the pericranium. This has ſeveral holes, which give paſſage to the ſpinal marrow, the nerves, arteries and veins.

veins. But theſe fill them ſo nicely, that nothing can paſs into, or out of the head, but through theſe veſſels.

It is round, that it may contain the more; but a little depreſſed and longiſh, advancing out behind, and flatted on the ſides, which contributes to the enlargement of the ſight and hearing.

It is divided into pieces by four ſutures. This makes it leſs liable to break, gives paſſage to the membranes of the pericranium, and vent to the matter of inſenſible perſpiration.

18. All theſe are involved in two membranes, the inner (called pia mater) extremely thin; the outer (called dura mater) conſiderably harder and thicker. Where they involve the cerebellum, there is interpoſed between them the arachnoides, a very ſubtle and tranſparent membrane, which deſcending through the hinder part of the ſkull, together with them involves the whole ſpinal marrow.

19. The outer part of the brain (called the cortex or bark) is of an aſhy or greyiſh colour. It is formed from the minute branches of the neighbouring arteries, which being wove together in the pia mater, encloſe the inner part, ordinarily to the thickneſs of about half an inch.

It conſiſts therefore of innumerable little glands, contiguous to each other, (ſuppoſed to ſecern the animal ſpirits) which are of themſelves oval, but by their mutual preſſure become angular, and run waving with each other.

The inner part (called the medulla) is white, and terminates in another medullary ſubſtance, very white and hard, called the corpus calloſum. The medulla is thought to conſiſt of fine tubes, which when collected into little bundles, and covered with membranes, are termed nerves.

20. To trace this a little farther. From every point of the outer brain ariſe minute fibres, which in their progreſs uniting together, are eaſily perceptible. Theſe conſtitute the ſubſtance of the inner brain, and of the ſpinal marrow. In their farther progreſs they are diſtinguiſhed

tinguiſhed by coats, detached from the two membranes of the brain, into ſeveral bundles called nerves, reſembling ſo many horſe-tails, each wrapt up in a double tunic.

Several of theſe part from the reſt, in the brain itſelf, of which there are ten pair; one on each ſide. From the ſpinal marrow there ariſe thirty pair more. All theſe, while within the ſkull or the ſpine, are pulpous; but afterwards harden, acquire a coat, and ſpread through the ſmalleſt points of the ſolid parts of the body. Their coats are every where furniſhed with blood-veſſels, lymphatics, and veſicles of a very tight texture, which ſerve to collect, ſtrengthen, and contract their fibres. And if we conſider, 1. The great bulk of the brain, cerebellum, and ſpinal marrow, (whereof the whole ſubſtance goes to conſtitute nerves, being continued into, and ending in them:) 2. The great number of nerves diſtributed hence, throughout the whole body: 3. That the brain and ſpinal marrow are the baſis of an embryo, whence the other parts are afterwards formed: And laſtly, That there is ſcarce any part of the body, which does not feel or move: it may ſeem not altogether improbable, that all the ſolid parts of the body, are woven out of nervous fibres, and wholly conſiſt of them.

21. The brain is divided into four ventricles. Near the riſe of the fourth, there is a round hole, over which is ſuſpended the pineal gland, ſo called from its reſembling the ſhape of a pine-apple. It is furniſhed with veins and arteries, and encloſed in a thin membrane, derived from the pia mater. Des Cartes imagined this to be the ſeat of the ſoul; but without any ſolid reaſon. Nor has any one yet been able to diſcover, what is the uſe of it.—Is it ſuch a reſervoir of blood for extraordinary occaſions, as ſome imagine the ſpleen to be?

The brain is abundantly bigger in proportion in man than in other animals. In other animals, it is commonly biggeſt, cæteris paribus, in thoſe that have moſt ſagacity.

There are in the brain multitudes of veſſels, ſo extremely ſmall, that if a globule of blood (a million of which exceed not a grain of ſand in bigneſs) were di-

vided

vided into 500 parts, thoſe parts would be too large to paſs through them. And theſe veſſels are as large in the brain of a ſparrow, as in that of an ox. Nor is there any difference between the brain of a large animal and a ſmall, but that one contains far more of theſe veſſels than the other. But the globules of the fluid paſſing through them are in all animals of the ſame ſize.

The outer part of a turkey's brain is a very clear and tranſparent oily matter. Innumerable fine blood-veſſels are ſpread through every part of this. And if a ſmall part is cut, there flows out a ſmall globule of pellucid fluid.

The brain is not abſolutely neceſſary to animal life. Infants have been born, and lived ſome time without any. We have an authentic account from Paris, of a child that ſurvived the birth four days, not only without a brain, but even a head: inſtead of which it had a maſs of fleſh, ſomewhat like liver. In 1763, a child was born alive without any brain, cerebellum, or medulla oblongta; the ſkull being ſolid: nor had it any communication with the ſpinal marrow. Mr. Du Verney took out the brain and cerebellum of a pigeon: yet it lived and walked about. Monſ. Chirac took out the brain of a dog; yet he lived. On taking out the cerebellum, he ſeemed dead; but revived, when he blew into the lungs, and continued alive an hour. Nay, there are many inſtances of inſects living a long time, after their head is cut off. Hence it appears, that the ſpinal marrow alone may, for a ſeaſon, ſuffice both for life, ſenſation and motion.

Are there diſtinct proviſions for the vital or ſpontaneous, and for the animal or voluntary actions? And does the cerebellum furniſh the heart, and other vital organs with nerves, while the brain ſupplies the nerves, which go out to the organs of ſenſe and voluntary motion? This is an elegant ſyſtem, but is every where confuted by anatomy. From the cerebellum, the fifth pair of nerves is manifeſtly produced; but this goes to the tongue, to the muſcles of the outward ear, of the eye, and of the noſe, which are parts, all of them either moved by the will, or elſe deſtined to ſenſation. Again, from one and the ſame nerve there are vital

branches

branches ſent to the heart and lungs, and others that are animal and voluntary to the larynx, or ſenſitive in the ſtomach. Laſtly, the repeated accounts of injuries to the cerebellum, being ſo ſpeedily fatal, are not altogether true; for that both wounds and ſcirrhoſities of this part have been ſuſtained without any fatality to the patient, may be affirmed by certain experience.

22. The eyes next offer themſelves to our obſervation, guarded by the eye-lids, eye-laſhes, and eye-brows. The eye-lids conſiſt of the cuticle, the ſkin, a thin expanſion of the panniculus carnoſus, and an inward coat. A paliſade of ſhort, but ſtiff hairs grows out of their cartilaginous edge, both to break the too fierce impreſſion of the rays of light, and to prevent any thing from getting into the eye, when open. Theſe hairs only grow to a convenient length, and their points ſtand out of the way; thoſe of the upper eye-lids being bent upward, and thoſe of the lower, downward. Mean time the eye-brows hinder ſweat, or any thing elſe which might be hurtful, from falling down from the forehead.

Both the eye-lids are moveable; but chiefly the upper. Animals which have hard eyes, as lobſters, need none, and therefore have no eye-lids. But moſt brutes have an additional eye-lid (called the nictitating membrane) which draws like a curtain, to wipe off what might incommode the eye. The monkey indeed has it not, as being furniſhed with hands like a man.

23. The eye can move upward, downward, to either ſide, and round, either toward the right or left. For theſe ſix motions, ſix muſcles are allotted, which ſpread their tendons far into the eye. At each inner corner of the eye, there is a gland with two or three ducts, which opening on the inner ſurface of the eye-lid, keep the eye-ball moiſt, to facilitate its motion. By theſe glands, tears alſo are ſecerned. The eye is connected with the ſurrounding bones by the tunica adnata, commonly called the white of the eye: in the midſt of which is a large hole for the tunica cornea, through which the iris and pupil appear. The whole ball of the eye riſes from the optic nerve, and is formed of

three

three coats, propagated from it, and as many humours: two of which, have each a coat of its own alſo. The eye therefore has five coats in all: three common, and two to contain their ſeveral humours.

24. The outermoſt coat, proceeding from the dura mater, and ſurrounding the whole eye, is termed the ſclerotica: the fore part of it being tranſparent like horn, is thence ſtiled the cornea. This is more convex than the reſt of the eye. It is compoſed of ſeveral parallel plates, which are nouriſhed by many blood-veſſels; but ſo fine, as not to hinder the ſmalleſt rays of light. It has an exquiſite ſenſe, that on the leaſt touch of any thing, the tears may be expreſſed, to waſh off any filth, which by adhering to it might render it dim or cloudy. The reſt of the ſclerotica is opaque, and of the ſame colour with the dura mater.

The ſecond coat is called the uvea. It is much thinner than the former, though thicker than the pia mater, from which it proceeds. In the forepart of it is a round hole, which with the chryſtalline humour interpoſed, conſtitutes the pupil, ſurrounded by the iris, ſo named, from its ſuppoſed reſemblance to the colours of the rainbow. The third and inmoſt coat is termed the retina. It is extremely thin and ſoft, and darker-coloured than the lower part of the optic nerve, of which it is a continuation.

"If it be queſtioned, ſays Dr. Haller, whether the object is painted upon the retina, or upon the choroides; we anſwer, this late ſuppoſition is inconſiſtent with known obſervation, by which the retina is evidently a moſt ſenſible expanſion of the nerve, while the choroides has only a few nerves, with ſmall veſſels, which are certainly blind. It is alſo oppoſed by the great variety of the choroides in different animals, while the conſtant uniformity of the retina is equally remarkable; to which add the black membrane, that is interpoſed betwixt the retina, and choroides, in ſome kinds of fiſh. Finally, anatomy demonſtrates, that the choroides is ſeated in the blind part of the eye, but is itſelf of a white colour."

25. The

25. The aqueous humour, reſembling the colour and conſiſtence of water, lies in the forepart of the eye, juſt behind the cornea: its interior ſurface is convex; the other, a little concave. Whence this humour is derived we cannot tell: but its ſource muſt be plentiful: for if the coat containing it be ſo wounded, that all the humour runs out, it needs only to keep the eye cloſe for a ſeaſon, and the wound will heal, and the humour recruit.

Indeed an eminent Italian affirms, that he has ſlit the pupil of divers animals, and ſqueezed out all the humours, and has afterwards reſtored them perfectly to ſight: nay, that the eyes of many, inſtead of being damaged thereby, ſeemed more lively and vigorous than before.

The ſecond humour, termed (improperly enough) the chryſtalline, conſiſts of many thouſand filaments, tending from the circumference to the centre, and cloſely woven together. It is a little convex before, and more behind. It ſerves to refract the rays of light, ſo that they may meet and form an image, on the bottom of the eye. It is ſet in the forepart of the vitreous humour, like a diamond in its collet, and is retained there by a membrane that ſurrounds it, thence called its capſula. It is toward the outſide like a jelly; but toward the centre as hard as ſalt. The figure of the outer part is varied by a ligament annexed, which can make it either more or leſs convex, or move it to or from the retina. And this is abſolutely neceſſary, in order to diſtinct viſion: for as the rays of diſtant objects diverge leſs than thoſe of near objects, the chryſtalline muſt either be made leſs convex, or be ſet farther from the retina.

When dried, it appears to conſiſt of a vaſt number of thin, round ſcales, one upon another, 2000 of which have been counted in one chryſtalline. Each of theſe conſiſts of a ſingle fibre, wound this way and that, in a ſtupendous manner, ſo as to run ſeveral courſes, and meet in as many centres, and yet not interfere or croſs in any place.

The third, which is termed the vitreous humour, is not unlike melted glaſs. It is covered with an exceeding

ing thin coat. The forepart is concave, as receiving the chryſtalline; the other ſide is convex.

The whole apparatus of the eye tends to this, that there be produced in the bottom of it, a diſtinct collection of all the rays, which proceeding from any point of an object, penetrate the chryſtalline humour, that ſo an image of that object may be painted there. In order to this, the rays ſtriking on the cornea, are reflected toward perpendicular, and thus directed through the pupil to the chryſtalline. Mean time the iris, contracting or dilating the pupil, admits fewer or more rays, as the object is more or leſs vivid.

Now the flatter the cornea is, the fewer rays does it collect and tranſmit to the chryſtalline, and thoſe more diverging. The rounder it is, the more rays does it collect and tranſmit, and thoſe more converging. It is too flat in old men; it is too round in them that are ſhort-ſighted. The rays tranſmitted through the pupil to the chryſtalline humour, are there refracted anew, collected and rendered converging, and thoſe that come from the ſame point, are thrown in one point on the bottom of the eye. But if the chryſtalline be too denſe, the focus (or point wherein they unite) will be too near: if that be not denſe enough, it will be too remote. And this is another cauſe of ſhort-ſightedneſs, or the contrary defect.

In all viſion both the eyes are uſed at once. And both together (as any one will find upon trial) behold an object in another ſituation than either of them apart would do. Hence a gentleman who had one of his eyes ſtruck out, for ſome months after was apt to miſtake the ſituation of things: and when he attempted to pour liquors into phials, often poured them quite beſide the neck of the phials.

Two eyes greatly contribute, if not to diſtinct, at leaſt to extenſive viſion. When an object is placed at a moderate diſtance, by the means of both eyes we ſee a larger ſhare of it than we poſſibly could with one; the right eye ſeeing a greater portion of its right ſide, and the left eye of its correſpondent ſide. Thus both eyes in ſome meaſure ſee round the object; and it is this that gives it in nature, the bold relievo, or ſwelling, with which it appears; and which no painting, how exquiſite ſoever, can attain to. The painter muſt be contented

tented with ſhading on a flat ſurface; but the eyes in obſerving nature, do not behold the ſhading only, but a part of the figure alſo, that lies behind thoſe very ſhadings, which gives it that ſwelling, which painters can never fully imitate.

There is another defect, which either of the eyes, taken ſingly, would have, but which is corrected, by having the organ double. In either eye there is a point, which has no viſion, ſo that if one of them only is employed in ſeeing, there is a part of the object to which it is always totally blind. This is that part of the optic nerve where its vein and artery run; that point of the object that is painted there, muſt continue unſeen. To be convinced of this, we have only to try a very eaſy experiment. If we take three black patches, and ſtick them upon a white wall, about a foot diſtant from each other, each about as high as the eye that is to obſerve them; then retiring ſix or ſeven feet back, and ſhutting one eye, by trying for ſometime, we ſhall find, that while we diſtinctly behold the black ſpots that are to the right and left, that which is in the middle remains totally unſeen. When we bring that part of the eye, where the optic artery runs, to fall upon the object, it will become inviſible. This defect, in either eye, is corrected by both, ſince the part of the object that is unſeen by one, will be diſtinctly perceived by the other.

The form of the eye is the moſt commodious which can be imagined. It is fitteſt both to contain the humours within, and to receive the images of objects from without. Was it ſquare, or of any multangular form, ſome of its parts would lie too far off, and ſome too nigh thoſe lenticular humours, which by their refractions cauſe viſion. But by means of this form, the humours are fitly placed to perform their office of refraction, and the little darkened cell neatly adapted to receive the image of the object.

Again. As it is neceſſary for the eye to move various ways, in order to adjuſt itſelf to various objects; ſo by this figure it is well prepared for ſuch motions, and can with eaſe direct itſelf as occaſion requires.

No leſs commodious is the ſituation of the eye: in the moſt eminent part of the body, and near the moſt

ſenſible

ſenſible part, the brain. By its eminence in the body, it can take in the more objects: and by its ſituation in the head, beſide it nearneſs to the brain, it is moſt conveniently placed for defence and ſecurity. In the hand it might have been more ready for ſervice: but to how many dangers would it have been expoſed? The ſame may be ſaid, as to its ſite in any other part but where it is. But the head is a part that ſeems contrived and made, chiefly for the uſe of the principal ſenſes.

Some odd circumſtances relative to the eyes, are related by a phyſician in the Philoſophical Tranſactions.

"A perſon had no viſible diſeaſe in his eyes; yet could not ſee, unleſs he ſqueezed his noſe with his fingers, or ſaddled it with narrow ſpectacles, and then he ſaw very well.

"A maid, 23 years old, could ſee very well, but no colour beſides white or black. She could ſometimes, in the greateſt darkneſs, ſee to read almoſt a quarter of an hour.

"A ſadler's daughter had an impoſthume, which broke in the corner of her eyes. And out of it there came about thirty ſtones, as big as ſmall pearls.

"A young man in Suffolk, about twenty years of age, has all the day a clear and ſtrong ſight. But when twilight comes, he is quite blind; nor can he ſee any thing at all, either by fire-light or candle-light. No glaſſes give him any help. He has been thus, ever ſince he can remember. This cloudineſs comes gradually upon him, like a miſt, as day-light declines. It is juſt the ſame, both in ſummer and winter, and at all times of the moon.

"When I was about ſixty, my ſight was ſo decayed, that I could not diſtinguiſh men from women. I received no help from any glaſſes, till I took ſpectacles with the largeſt circles. Cloſe to the upper ſemicircle on both ſides, I cut the bone, and taking out the glaſſes, put black Spaniſh leather, taper-wiſe, into the emptied circles. Theſe took in my whole eye at the wider end, and through the narrower end I can read the ſmalleſt print. Into this end I can only put my little finger, not quite to the firſt joint. But they may be made wider or narrower, and longer or ſhorter, as beſt fits every eye.

"At

"At firſt I could not bear them above two hours at a time: now I can uſe them above twelve hours in four and twenty. And they prove a great help to thoſe who are purblind, who have weak eyes, or decayed with age. But for the purblind they muſt be made ſhorter: longer for eyes decayed with age.

"Inſtead of leather, they may be made of paper, coloured black and paſted on; and with inner folds to be drawn out, from one inch to three."

In ſome men the iris has a faculty of darting out light. Dr. Willis mentions one, who after drinking wine plentifully, could ſee to read in the darkeſt night. And Pliny records of Tiberius Cæſar, that if he waked in the night, he could ſee every thing for awhile, as in the broad day-light. Dr. Briggs gives a parallel inſtance of a gentleman in Bedfordſhire.

We find various ſubſtitutes for the uſe of the eyes, in many blind perſons. In ſome the defect has been ſupplied, by an excellent gift of remembring what they had ſeen: in ſome by a delicate ſenſe of ſmelling; in others, by a fine ſenſe of hearing. So Richard Clutterbuck of Redborough in Glouceſterſhire, who was ſtone-blind, had ſo curious an ear, that he could hear the fine ſand of an hour-glaſs fall. In ſome it has been ſupplied by an exquiſite ſenſe of feeling: ſo that the ſame Richard Clutterbuck was able to perform all ſorts of curious works. He could not only take a watch in pieces, and ſet it together again, but could alſo make all ſorts of ſtringed inſtruments of muſic. He likewiſe played on them by notes cut in their uſual form, and ſet upon protuberant lines on the wood. Yet even this hardly came up to the ſkill of Van-Eyck, the organiſt of Utrecht, who, though he had been blind from two years old, played on all ſorts of inſtruments.

Others have been able to take a face by the touch, and mould it in wax with the utmoſt exactneſs: as was the blind ſculptor, who thus took the likeneſs of the Duke de Bracciano, and made a marble ſtatue of King Charles I. extremely well.

26. But more than all this, ſome perſons have been able even to diſtinguiſh colours by the touch. Peter

of

of Maeſtricht, though perfectly blind, diſtinguiſhed by his touch the different colours of cloth. John Vermaaſen of Utrecht did the ſame; judging by the different degrees of roughneſs which he felt.

Yet blind perſons, even though they diſtinguiſh them by the touch, have no idea of viſible objects. Thus the gentleman couched by Dr. Cheſſelden: he had no idea of diſtance, but imagined all the objects he ſaw, touched his eyes, in the ſame manner as thoſe he felt did his ſkin.

An extract from Dr. Cheſſelden's account of this perſon, will not be unacceptable to the curious.

"This young gentleman could in a ſtrong light diſtinguiſh black, white, and ſcarlet. Yet the faint ideas he had of them before he was couched, did not ſuffice to make him know them after. He now thought ſcarlet the moſt beautiful of all colours. Of others, the moſt gay, were the moſt pleaſing. But the firſt time he ſaw black, he was very uneaſy; yet after awhile he was reconciled to it. When he firſt ſaw, no objects were ſo agreeable to him, as thoſe that were ſmooth and regular: although he knew not the ſhape of any thing, nor could diſtinguiſh one from another, either by its ſhape or ſize. Being told what thoſe things were, whoſe forms he knew by feeling, he would carefully obſerve, that he might know them again. Thus having often forgot, which was the cat and which the dog, he was aſhamed to aſk: but catching the cat, (which he knew by feeling) he looked at her ſteadfaſtly, and ſaid, "So, puſs, I ſhall know you another time." He was ſurpriſed, that the things or perſons he liked beſt, did not appear moſt agreeable to his ſight, expecting that what was moſt pleaſing to his other ſenſes, would be ſo to his ſight alſo.

"We thought he ſoon knew the nature of pictures; but found afterwards we were miſtaken: for it was two months after the operation, before he diſcovered that they repreſented ſolid bodies. Even then he was no leſs ſurpriſed, expecting they would feel like the things they repreſented. He was amazed, that thoſe parts, which by their light and ſhade appeared round and uneven, ſhould feel like the reſt, and aſked, which was the lying ſenſe, feeling or ſeeing? Being ſhewn his

his father's picture drawn in miniature, and told, what it was, he acknowledged the likeneſs; but aſked, how it could be, that ſo large a face ſhould be contained in ſo little room? Saying, it would have ſeemed as impoſſible to him, as to put a buſhel of any thing into a pint. But even blindneſs he obſerved, had this advantage, that he could go any where in the dark, better than thoſe that could ſee. And after he was couched, he did not loſe it, but could go all about the houſe without a light. Every new object gave him new delight, ſuch as he wanted words to expreſs. He was particularly delighted when he firſt ſaw a large proſpect, and called it a new kind of ſeeing. Being afterwards couched in his other eye, he ſaid that objects appeared larger to his eye; though not ſo large as they did to the other, when it was newly couched. But looking on them with both eyes they ſeemed twice as large, as if he looked with that only."

27. I would beg leave to propoſe a few queries here, to which I have not found a ſatisfactory anſwer.

1. Why do we ſee things falſe with one eye? Particularly with regard to their ſituation.

2. How do the two eyes compound the rays of light, ſo as to ſee right?

3. Why do we not ſee all things double?

4. Since all things are painted upſide down on the bottom of the eye, why do we not ſee them ſo?

28. We now proceed to the ear, formed with exquiſite wiſdom, for the conception of ſounds. The outward ear conſiſting of an oval cartilage, externally convex, concave within, leads by various windings to the meatus auditorius, which is firſt cartilaginous, and then bony. It is filled with a viſcid matter, called the ear-wax, which is ſupplied from the veſſels placed in the ſkin, ſurrounding the meatus, to hinder any hurtful animal from creeping into the ear. The meatus is cloſed within by a thin, dry, tranſparent membrane, affixed to a bony circle, which is called the membrana tympani. Behind it is the cavity of the os petroſum, which is termed the drum.

The outward ear has two parts, that which ſtands

out from the head, called the auricle, and the narrow paſſage which enters the ſkull, called meatus auditorius.

The auricle is furrowed with divers winding canals, which receive and collect the various undulations of the air. They who have loſt this, hear very confuſedly, unleſs they uſe a trumpet, or form a cavity round the ear, with their hands.

It is a wiſe proviſion, that the ſubſtance of the auricle is cartilaginous. Had it been bone, it would have been troubleſome, and might by many accidents have been broken off. If fleſh, it would neither have remained expanded, nor ſo well have received or conveyed the ſounds. Rather it would have blunted them, and retarded their progreſs into the organ. But being hard, and curiouſly ſmooth and winding, ſounds find an eaſy paſſage, with a regular refraction, as in a well-built arch.

It is obſervable, that in infants in the womb, and newly-born, the meatus auditorius is cloſe ſhut up, partly by the conſtruction of the paſſage, and partly by a glutinous ſubſtance, whereby the drum is guarded againſt the water in the ſecundine, and againſt the injuries of the air, as ſoon as the infant is born.

It is remarkable, that in the ear of moſt, if not all animals, where the meatus auditorius is long enough to afford harbour to ear-wigs, or other inſects; ear-wax is conſtantly to be found. But in birds, whoſe ears are covered with feathers, and where the drum lies but a little within the ſkull, no ear-wax is found, becauſe none is neceſſary to the ears ſo well guarded, and ſo little tunnelled.

29. In this, beſides a little branch of nerves, there are four little bones, two paſſages, and two windows. Three of thoſe bones, from ſome imagined reſemblance, are ſtiled the hammer, the anvil, and the ſtaple: the fourth is termed, the orbicular bone. Theſe are faſtened by ſtrong ligaments to each other, and to the neighbouring parts. The paſſages go from the ſide of the drum: one of which, termed the labyrinth, by a very winding way, carries a part of the auditory nerve to the external muſcles of the head. The other paſſes

from

from the bottom of the drum to the palate; whereby not only air, if needful, may be received, but the defect of hearing, in ſome meaſure ſupplied by ſpeaking to the mouth.

The labyrinth contains, beſides the entrance, three bony, ſemicircular cavities, and a bony canal, in the form of a ſcrew, divided into two parts, from the top to the bottom. The labyrinth is lined throughout with a thin membrane, furniſhed with veins, arteries and nerves. And this membrane may not improbably be the organ of hearing.

The curious ſtructure of the labyrinth and ſcrew, tend to make the weakeſt ſounds audible. Thoſe canals, by their winding, contain large portions of the auditory nerve, upon every point of which, at once the ſound being impreſt, becomes audible; and by their narrowneſs the ſounds are hindered from dilating, which muſt have weakened them proportionably.

The ſtrength of the impreſſion is likewiſe increaſed, by the elaſticity of the ſides of the bony canal; which receiving the firſt impulſes of the air, reverberate them on the auditory nerve.

The auditory nerves are diſtributed, one to the ear, the other to the eye, tongue, and parts adjoining. By the diſtribution thereof to different parts, an admirable conſent is eſtabliſhed between them. Hence it is, that moſt animals hearing a ſtrange ſound, erect their ears to catch it, open their eyes, and are ready with their mouth, to ſhriek or call for help. A farther uſe of this nervous communication between the ear and the mouth is, that the voice may correſpond with the hearing, and be a kind of echo thereof: and that what is heard with one of theſe nerves, may readily be expreſſed by the help of the other.

And now what leſs than an infinitely wiſe God, could contrive ſo fine an organ, and ſuch a medium, ſo ſuſceptible of every impreſſion, that the ſenſe of hearing hath occaſion for, to empower all animals to expreſs their meaning to each other, with endleſs variety? Yea, what leſs could form ſuch an œconomy as that of muſic is? So that the medium conveys the melodious vibration of every animal voice or well-tuned

inſtrument, and the ear receives them, to allay the perturbations, and calm and cheer the heart of man!

Though the ear be the ordinary organ of hearing, yet it is not the only one. We may hear by the teeth. For if one end of a knife be applied to a ſpinnet, and the other held between the teeth, the muſic will be diſtinctly heard, though the ears be ever ſo cloſely ſtopped. Yet this is not properly by the teeth, but by the auditory nerve which paſſes from the drum to the palate.

In thoſe who are born deaf, the eyes may in ſome meaſure ſerve in the place of ears. Some can underſtand what is ſaid, by nicely obſerving the lips and tongue of the ſpeaker: and may even accuſtom themſelves to uſe their own, till they learn a kind of ſpeech. Thus a phyſician at Amſterdam taught ſeveral children born deaf, to underſtand what was ſaid, and to give pertinent anſwers.

Mr. Goddy's daughter of Genoa loſt her hearing at two years old. Yet by obſerving the lips of others, ſhe had acquired many words, whereby ſhe would talk whole days with thoſe that could underſtand her. But ſhe knew nothing of what was ſaid, unleſs ſhe ſaw the mouth of the ſpeaker: ſo that if they wanted to ſpeak to her in the night, they were obliged to light a candle. Only ſhe knew what her ſiſter ſaid even in the dark, by laying her hand on her mouth.

Bnt many deaf perſons can hear, if a loud noiſe be made while you ſpeak. Dr. Willis mentions one, who, if a drum was beat in the room, could hear very clearly. So that her huſband hired a drummer for his ſervant, and by that means converſed with her daily.

30. The noſtrils are made not of fleſh or bone, but of cartilage, the better to be kept open, and as occaſion requires, to be dilated or contracted: for which purpoſe they are furniſhed with proper and curious muſcles. The tubes therein growing narrower and narrower, lead into ſeveral little cells and winding cavities, covered with a ſoft coat, and provided with arteries, veins, glands, and filaments of the olfactory nerves. This therefore is without all doubt the proper organ of ſmelling.

And

And foraſmuch as it is by breathing, that the odorant particles are drawn in, the laminæ with which the upper part of the noſe is barricaded, ſerve two excellent purpoſes; partly to prevent any thing hurtful from entering the breathing paſſages in our ſleep (for which end likewiſe the hairs placed at the entrance of the noſtrils ſerve) and partly to receive the divarications of the olfactory nerves, which are here thick ſpread, and by this means meet the ſmells entering with the breath.

Each of the cartilaginous laminæ is divided into many others, folded into a ſpiral line. This os cibroſum is made up of the extremities of theſe; the holes therein being the intervals between them. They are deſigned to uphold the inner tunic of the noſe, which is folded round about together with theſe laminæ, that by its great expanſion it may receive a greater number of the odorant particles. For the ſame reaſon, it is furniſhed with many ſmall glands, which open into it, and moiſten it with a ſlimy exudication, fitted to entangle and detain the ſubtle effluvia that touch it. And not only the number, but alſo the length of theſe laminaæ, is of great uſe for the ſtrength of ſmelling. For this purpoſe moſt beaſts, which either hunt, or diſtinguiſh their food by ſmell, have not their noſe in the middle of their face, like a man, but prolonged to the very end.

31. The tongue has for its baſis that forked bone, called the os gutturis. It conſiſts of various muſcles interwoven together, that it may be fit for various kinds of motion. To theſe are added very many ſmall branches of nerves, which paſs through the middle of it to the outſide, and being gathered into little bundles conſtitute thoſe papilæ, which makes its ſurface rough and uneven. Beſides theſe, there appear alſo on the ſurface of the tongue, certain pointed fibres, not unlike the ends of birds claws, inclining toward the baſis of it, with which are interſperſed innumerable ſalival glands. And all theſe are in their ſeveral ways ſubſervient to the ſenſe of taſting.

It has been generally ſuppoſed, that the tongue is eſſentially neceſſary to the formation of ſpeech. But

as

as ſure as we have been of this opinion, it is an entire miſtake. A child in Eſſex, ſome years ago, had her tongue entirely cut out, by reaſon of an incurable canker. She was then three years old. Twenty years after, it was reported, that ſhe was able to ſpeak. To be ſatisfied hereof, Mr. Benjamin Boddington, Turkey-merchant of Ipſwich, with two other gentlemen, went to Wickham-market, where the young woman then lived, whoſe caſe they thus deſcribe.

" We have this day been at Wickham-market, to ſatisfy ourſelves concerning Margaret Cutting. We examined her mouth with the greateſt exactneſs, but found no part of the tongue remaining; nor was there any uvula. The paſſage down the throat is a circular open hole, large enough to admit a ſmall nutmeg.

" Notwithſtanding this, ſhe ſwallowed both ſolids and fluids as well as we could do, and in the ſame manner. Yea, and ſhe talked as fluently as other perſons do. She pronounced letters and ſyllables very articulately, even thoſe which ſeem neceſſarily to require the help of the tongue, as d, l, t, w. She read to us in a book diſtinctly; ſhe ſings very prettily: nay, and ſhe diſtinguiſhes taſtes, and can tell the leaſt difference either in taſte or ſmell.

But is it poſſible to teach any one to ſpeak, who has been deaf and dumb from his birth!—

It is. Dr. Wallis taught ſuch an one to ſpeak: Mr. Daniel Whaley, of Northampton. He was preſent before the Royal Society, May 21, 1662, and did there pronounce, diſtinctly enough, ſuch words as the company propoſed to him: indeed not altogether with the uſual tone, yet ſo as eaſily to be underſtood. In a year, which was the time he ſtayed with Dr. Wallis, he read over great part of the Engliſh Bible, and learned to expreſs himſelf intelligibly in common affairs, to underſtand letters written to him, and to anſwer them. And in the preſence of many foreigners, he has not only read Engliſh and Latin to them, but has pronounced the moſt difficult words in their languages, which they could propoſe to him.

The Doctor has ſince done the ſame for Mr. Alexander Popham, a gentleman of a fair eſtate.

But

But we have an inſtance of dumbneſs cured in a ſhorter time. Henry Axford, ſon of Henry Axford, in the Devizes, at twenty-eight years of age, perceived a hoarſeneſs, and in about ſix days became quite ſpeechleſs; not only unable to ſpeak articulately, but to utter the leaſt ſound with his tongue. His cold went off, but he remained abſolutely ſpeechleſs; and the advice of all the neighbouring phyſicians did not help him.

He continued totally dumb for four years, till in July 1741, being at Stoke, in returning homeward at night, he fell from his horſe, and was taken up and put to bed in a houſe upon the road. He ſoon fell aſleep, and dreamed, he was fallen into a veſſel of boiling wort. Struggling with all his might to call for help, he actually did call aloud, and recovered the uſe of his tongue from that moment, as perfectly as ever he had it in his life.

Perhaps therefore there is truth in that ancient ſtory, concerning the ſon of king Crœſus: namely, having been dumb from his birth, he had never ſpoke at all, till in the battle, ſeeing a man ready to kill his father, his tongue was looſed, and he cried out aloud, "Soldier, ſpare the king!"

The time of cutting the teeth is uſually from the ſeventh to the ſeventeenth month. It is commonly preceded by an itching of the gums, and by convulſions, fevers, and looſeneſs: moſt of which ſymptoms happen to birds alſo, upon moulting or caſting their feathers. The ſeed of the teeth is a mucous matter, like the white of an egg, contained in the cells of the jaw-bone, which grows harder and bigger till it breaks through the gum.

That part of the tooth which ſtands out of the gum, is covered with a peculiar ſubſtance called enamel. It is compoſed of an infinity of little tubes, which grow on the bone by their root. If any part of this be broken off, ſo that the bone is left bare, it grows carious; there being no bone which will bear the air.

We may farther obſerve, 1. That the teeth only, of all the bones, grow in length during a man's whole life: which is providentially deſigned, to repair the waſte that is continually made by attrition: 2. That the

the teeth are the only bones which are not covered with that exquiſitely ſenſible membrane, the perioſteum: 3. That they are harder and firmer than any other bone, that they may be more durable and fit to chew the moſt ſolid aliments: 4. That for their nouriſhment, there is a cavity contrived in each ſide of the jaw-bone, in which are lodged an artery, a vein, and a nerve, which through ſmaller cavities ſend their twigs to every tooth: 5. That as infants are deſigned to live on milk, for ſome months; they are ſo long without any teeth: whereas animals that need them, have them ſooner, and ſome are even born with them. 6. The different ſhape of the teeth is remarkable. The fore-teeth are formed broad, and with a thin and ſharp edge, like chiſſels, to cut off a morſel from any ſolid food. The next, one on each ſide, are ſtronger, deeper-rooted, and more pointed, to tear tougher aliments: the reſt are mad flat and broad at top, and withal, ſomewhat uneven, that thereby they may the better retain, grind and mix the aliment. 7. Becauſe biting and chewing require much ſtrength, partly in the teeth themſelves, partly in the inſtruments that move the lower jaw, which alone is moveable; nature has given it ſtrong muſcles, which make it bear forcibly againſt the upper jaw: and has not only fixt each tooth in a diſtinct cavity, as in a cloſe, ſtrong and deep ſocket; but has given holdfaſts to the ſeveral ſorts of teeth, ſuitable to the ſtreſs that is to be laid upon them. So whereas the cutters and eye-teeth have only one root, the grinders, deſigned for harder work, have three: in the upper jaw often four, becauſe they are pendulous, and the ſubſtance of the jaw ſomewhat ſofter. 8. The ſituation of the teeth is moſt convenient. The grinders are behind, near the centre of motion, becauſe chewing requires a conſiderable force: the cutters before, ready for their eaſier work.

32. The palate is of a bony ſubſtance, a little concave, and clothed with a thick membrane, which has the ſame kind of nervous papillæ and ſmall glands, that are ſeen in the ſurface of the tongue. And hence it is qualified to aſſiſt the taſte, as well as the ſpeech.

It

It would be endleſs to ſpecify the curious mechaniſm of all the parts that concur to form the voice. However, let us note two things: 1. There are thirteen muſcles provided for moving the five cartilages of the wind-pipe. 2. It is amazing that the glottis, (the upper part of the wind-pipe) can ſo exquiſitely contract or dilate itſelf, to form all notes. "Suppoſe (ſays Dr. Keil) the greateſt diſtance of the two ſides of the glottis to be one tenth of an inch, in ſounding twelve notes (to which the voice eaſily reaches) this line muſt be divided into twelve parts, each of which gives the aperture requiſite for ſuch a note. But if we conſider the ſubdiviſion of notes into which the voice can run, the motion of the ſides of the glottis is ſtill vaſtly nicer: for if of two chords, ſounding exactly uniſons, one be ſhortened but the two thouſandth part of its length, a juſt ear will perceive the diſagreement, and a good voice will ſound the difference; and yet this is only the one hundredth and ninety-ſixth part of a note. But ſuppoſe the voice can divide only into a hundred parts, it follows, that the different apertures of the glottis, actually divide the tenth part of an inch, into twelve hundred parts, the effect of each of which produces a ſenſible alteration upon a good ear."

33. The uvula is a round, oblong, fleſhy ſubſtance, ſuſpended near the paſſage from the mouth into the noſtrils, and probably deſigned to hinder the cold air, from ruſhing too faſt into the lungs, as well as to prevent the food we ſwallow from regurgitating into the noſtrils.

The tonſils, or almonds of the ear, are two ſmall glands, placed at the root of the tongue, which ſupply an humour, to keep the mouth and the tongue continually moiſt.

The wind-pipe is wonderful in its conformation: becauſe continual reſpiration is neceſſary, it is made with annular cartilages, to keep it conſtantly open, that its ſides may not fall together: and leſt, when we ſwallow, any particle of food ſhould fall in, which might cauſe convulſions, or even death, it has a ſtrong ſhutter, or lid, called the epiglottis, which, whenever we eat or drink, falls down of itſelf, and covers it cloſe,

ſo that no crumb or drop can enter. It is for the more convenient bending of our necks, that the wind-pipe is not made of one entire continued cartilage, but of many circular ones.

What is farther remarkable in theſe cartilages is, that all the way where they are contiguous to the gullet, they are membranous, to give an eaſy paſſage to the food: but after that, they are, ſome completely round, ſome triangular. Another thing obſervable is, in the wind-pipe, the cartilages run parallel to each other: but, in the lungs, the lower parts of the ſuperior cartilages, receive the upper parts of the inferior: hereby enabling them to contract themſelves in expiration, and to dilate in inſpiration.

34. The hairs are all hollow. The root of each hair is fixt in a mucous globule, of an oval figure, which often adheres to it, when it is pulled up by the root. They are jointed like a reed or cane, and ſhoot out into ſmall branches. They ſerve not only for a covering, but alſo for the excretion and expiration of an oily matter.

Every hair does properly live, and receive nouriſhment like the other parts. The roots do not turn white or grey in age, any ſooner than the extremes. But the whole of each hair changes colour at once. Or (to ſpeak more properly) the hairs of another colour fall off, and white ones grow in their place.

But extreme fear may turn the hair grey, or even white in a ſhort ſpace. So it was in that famous inſtance ſome years ago. A nobleman, in Germany, was condemned to die, and ordered for execution in the morning. During the night, in ten or twelve hours time, all his hair turned white as flax. The Emperor being informed of this, ſaid, "He has ſuffered enough:" and pardoned him.

Since that time, there has been an inſtance of one of our own countrymen, who being ſhip-wrecked, ſaved himſelf on a ſmall rock, ſurrounded by the ſea. A boat took him off after he had ſtayed there four hours. But in that ſpace his hair was turned quite white.

Perhaps

Perhaps a ſtill ſtranger inſtance of this kind is related in the Duke of Sully's Memoirs. "Henry IV. told the Marquis de la Force, That the moment he was informed, Henry the III. had publiſhed an edict, (in July 1585) ordering all the Hugonots either to go to maſs, or to abandon the kingdom in ſix months, his muſtaches turned ſuddenly white on that ſide of his face, which he ſupported with his hand."

Its life is a peculiar kind, and approaches to the nature of vegetation. Hairs grow much as plants grow out of the earth, or as ſome plants grow upon others: from which they draw their nouriſhment, and yet each has its life diſtinct from the other. So hair derives its food from ſome juices in the body; but not from the nutritious juices. Accordingly the hair may live and grow, while the body is ſtarved to death.

That hair may grow, merely as an excreſcence of the vegetable kind, appears from that memorable caſe recited by Mr. Hook, of a body which, having been buried forty-three years, was found in a manner wholly converted into hair. The woman was buried in a coffin of wood, and lay the loweſt of three in the ſame grave. The others, being removed, and this coffin appearing, it was obſerved, that much hair came through the clefts of it: on removing the lid, the whole appeared a very ſurpriſing ſight. There was the whole figure of the corpſe, exhibiting the eyes, mouth, ears, and every part. But from the very crown of the head, even to the ſole of the foot, it was covered over with a very thick ſet hair; long, and much curled. The people, amazed, at this appearance, went to touch the corpſe. But the ſhape fell away, as it was handled, leaving only a quantity of ſhapeleſs hair; but neither fleſh nor bones, only a ſmall part of the great toe of the right foot.

Each hair conſiſts of ſeveral ſmaller ones, wrapt up in one common covering. They ſend out branches at the joints. The root lies pretty deep in the ſkin: and by this they imbibe their proper nouriſhment, from the adjacent humours. Their extremes alſo ſplit into two or three branches, eſpecially if they are very dry, or too long. So that what appears a ſingle hair to the naked eye, to the microſcope appears a bruſh. They

are

are grey on the fore part of the head firſt, particularly about the temples: the back part affords them nouriſhment longer. For the ſame reaſon they fall from the crown of the head firſt. Their thickneſs depends on the ſize of the pores they iſſue from: if theſe are ſmall, the hair is fine. If the pores be ſtraight, the hairs are ſtraight; if oblique or ſinuous, the hairs are curled.

All hairs appear round. But the microſcope diſcovers ſome of them to be ſquare, others triangular; which diverſity of figures ariſe merely from the diverſity of the pores. Their length depends on the quantity of humours proper to feed them, and their colour on the quality. And hence the colour uſually differs in the different ſtages of life.

The hair of a mouſe is a tranſparent tube, with a pith of ſmall fibres convolved, running in ſome hairs ſpirally, in ſome tranſverſely, in others from top to bottom.

The nails are of the nature and fabric of the cuticle, like which, they are alſo inſenſible, and renewable, after being cut or fallen off. They are placed upon the backs of the ends of the fingers and toes, which they ſupport to make a due reſiſtance in the apprehenſion of objects, having the nervous papillary bodies, that ſerve the organ of touch, placed under their lower furface. They ariſe with a ſquare root, intermixed with the perioſteum, a little before the laſt joints, from betwixt the outer and inner ſtratum of the ſkin, and paſſing on ſoft, go out by a lunar cleft in the external plate of the ſkin, where the cuticle returns back, and enters into a cloſe adheſion with the root of the nail, together with which it is extended as an outer covering.

35. We proceed to the middle cavity of the body. Herein the principal part is the heart, conſiſting of a ſtrong tendon, extended obliquely from the baſis or broader part, to the cone, into which the fleſhy fibres are inſerted, in an elegant ſeries, with a ſpiral bending, one half oppoſite to, and croſſing the other: by which means the grand muſcle is admirably fitted both to receive and to propel the blood. It has two great cavi-

ties,

ties, uſually termed the ventricles of the heart. They are divided from each other by an intermediate part, called the ſeptum, conſtituted by the ſame fibres, which is convex on the ſide next the right ventricle, and concave on the other. The vena cava is inſerted in the right ventricle, and two inches from its inſertion, divides into the upper and lower. The former brings the blood into it from the upper; the latter, from the lower parts of the body. The pulmonary artery carries the blood from that ventricle into the lungs, which the pulmonary vein brings from thence into the left ventricle. At the upper ſide of theſe veins, there is added to each ventricle, a kind of purſe called the auricle, which is a hollow muſcle of the ſame ſtructure with the heart, in order to ſtay the blood, that it pour not too violently into the ventricle. Before the orifices of the veins of the heart, there are triangular valves, and ſemilunar in the orifices of the arteries, to hinder the reflux of the blood, from the ventricles into the veins, and from the arteries into the ventricles. In a healthy perſon, the heart contracts little leſs than five thouſand times in an hour.

36. The heart is covered with a fine membrane; and near the baſe of it, on the outſide, there is a little fat, probably deſigned to facilitate its motion. It is placed near the middle of the breaſt; only its cone inclines a little to the left. It hangs by its baſe on veins and arteries, communicating with all parts of the body. The other part of it is looſe in the pericardium, that it may be the more commodiouſly conſtringed and dilated. The pericardium is a kind of membrane, that like a kind of purſe, looſely encloſes the heart. The ſhape of it is ſuited to that of the heart, and it contains a thin, ſaltiſh, reddiſh humour, exuding from the arteries.

The brain has an alternate contraction and dilation, anſwering thoſe of the heart. It is highly probable, the weight of the atmoſphere, is the counterpoiſe to the contractile force of the heart. That of the brain, being not near ſo ſtrong, does not need ſo ſtrong a counterpoiſe.

In

In the baſis of the heart, in ſome animals, there is a bone frequently found. Such an one was found in the heart of Pope Urban. Probably it was only the tendons of the heart oſſified.

Wounds of the heart are not always ſo immediately mortal as is generally ſuppoſed. A ſoldier was brought into one of the hoſpitals in Paris, with a wound in the upper part of the left breaſt. He ſeemed very well for three days: but on the fourth was taken with a fever and difficulty of breathing, and died on the tenth. On opening the body, it was found the ſword had pierced the pericardium, traverſed the right ventricle of the heart in its lower part, pierced the pericardium on the oppoſite ſide, and gone through the diaphragm, and an inch deep into the liver.

37. The heart is placed in the middle of the lungs, which conſiſt of two parts, the right and left lobe. Each of theſe is divided into two other lobes; one of theſe frequently into three, ſometimes into four, by fiſſures, ſometimes deeper, ſometimes ſhallower, running from the interior margin towards the back part. The lungs are divided into cells, which are no other than expanſions of the ſmall branches of the trachea or wind-pipe. And there is an eaſy paſſage from one branch into many cells, and again into it from them all. The upper part of the trachea opens into the mouth; the lower, divided into two branches, ſhoots out into various ramifications, which are termed bronchia. And theſe little canals running on, conſtitute the lungs, whoſe cells are wonderfully connected together, and intermixed with numberleſs branches of veins and arteries.

The upper end of the trachea is called the larynx. At the fourth vertebre of the back, it divides and enters the lungs. Its cartilages, ranged at ſmall and equal diſtances, are ſmaller and ſmaller as they approach the lungs.

Theſe cartilages have two membranes. The external, compoſed of circular fibres, covers the whole trachea. That which lines it within, conſiſts of three diſtinct membranes, the firſt woven of two orders of fibres, part longitudinal, to ſhorten it by drawing the cartilages

cartilages together: part circular, to contract them. Both theſe, together, with the external membrane, aſſiſt in breathing, coughing, and varying the tone of voice. The ſecond membrane is glandulous, and its glands opening into the cavity of the trachea, ſeparate a liquor which moiſtens and defends it from the acrimony of the air. The third is a net-work of nerves, veins, and arteries.

The organs which form the voice of man, have not been accurately obſerved by the ancients. As the trachea bears ſome reſemblance to a flute, they conſidered the voice, according to the ſounds of that inſtrument. Mr. Dodart was the firſt who ſhewed the glottis to be the chief organ in producing it, and conſidered it both as a ſtring and wind inſtrument, far more perfect than any which art can produce.

The organs which form the various voices of other animals, are likewiſe worthy of our attention. Thoſe of each ſpecies have peculiar ſounds, whereby they underſtand each other.—Wherein do theſe organs reſemble ours, and wherein do they differ?

The human voice is almoſt wholly formed by the glottis, and various tones are produced by the various modifications of it. But all theſe depend on one only; the ſeparation and junction of its lips. This comprehends two circumſtances, the one capital and primitive, the other, a conſequence of it. The firſt is, that the lips are more and more bent, from the loweſt to the higheſt note. The ſecond, that the more they bend, the nearer they draw to each other. It follows from the firſt, that their vibrations will be more frequent, as they come nearer the higheſt tone, and that the voice will be exact when they are equally bent, and the reverſe when unequally; which correſponds perfectly well with the nature of ſtringed-inſtruments. It follows from the ſecond, that the higher the tone, the nearer they draw to each other. And this agrees perfectly with thoſe wind-inſtruments which are governed by reeds. From theſe ſimple, and almoſt imperceptible variations, proceeds the infinite variety of ſounds.

In moſt quadrupeds too the glottis is the principal organ of the voice. So it is in cats, ſheep, and ſeveral others.

others. But many have ſomething more than a glottis. As horſes, aſſes, mules, and ſwine. Some of theſe have alſo a tendinous membrane, which concurs in forming the voice. Others have ſeveral membranes: others a kind of bags, which in ſome, are membranous, and in others, bony. Others have both membranes and bags. Others laſtly, have in their larynx a kind of cavity or drum, which aſſiſts them in uttering very ſtrong and long continued notes.

All ſounds are produced by a ſwift ſucceſſion of vibrations, from the particles of ſonorous bodies, which agitate the air. But the vibrations of the lips of the glottis would not ſuffice to produce the neighing of a horſe. This begins by more or leſs acute interrupted tones, accompanied by quaverings, and ends by tones more or leſs grave, which is performed by jirks. This ſecond part is done by the lips of the glottis: the other chiefly by a ſmall, elaſtic membrane. This is tendinous, very thin, of a triangular figure, and lies flat on each extremity of the lips of the glottis. As it adheres but looſely to theſe, it can eaſily flutter up and down: and it is the play of the membrane up and down, which produces the acute ſounds of neighing. Theſe are more or leſs acute, as the membrane is more or leſs thin, and its adheſion more or leſs ſlack. The grave ſounds that conclude the neighing, are excited by the flutterings of the thick ſtrings which form the lips of the glottis.

The hoarſe ſound of the aſs's voice, is not ſo much produced by the lips of the glottis, as by a tendinous part which adheres looſely on the aperture of a kind of drum, ſituate under the extremity of the lips of the glottis: above which are alſo found two large and thick backs; one on the right, the other on the left. Each of theſe has a roundiſh aperture, cut much like the ſtopple of an organ.

Such are the organs which form this amazing ſound. A kind of drum is the principal: and the two bags above the lips of the glottis, are the main auxiliaries: while theſe lips, as plain experiments ſhew, contribute very little thereto. The mule's voice much reſembles that of his ſire, and is formed by much the ſame organs:

gans: the drum of ſo ſingular a compoſition, being found in mules alſo.

There is another animal which affords us a particular diſpoſition of the vocal organs. This is the hog: whoſe ſhrill cries are more inſupportable than his uſual grunting. Yet neither are theſe excited by the lips of the glottis, but by the fluttering of two large membranous bags; ſituated on each ſide, above the lips of the glottis. What is moſt remarkable is, that each lid is cloven, almoſt its whole length. By this cleft each lip has a communication with the bag belonging to it. And the motions of theſe bags produce moſt of the ſounds peculiar to this animal.

Though the voice of birds bears a nearer reſemblance to ours, than that of a quadruped's, yet their organs have far leſs reſemblance to ours, and contain a greater number of ſingularities. They, like us, have a glottis at the top of the trachea; but they have another at the bottom of it, which much contributes both to the ſtrengthening and modifying of their voice. Theſe have different membranes more or leſs fine, more or leſs bent, and in a variety of poſitions. In ſome birds, as in geeſe, there are four of theſe, figured and diſpoſed like the reeds in hautboys.

With regard to the human voice, an ingenious man obſerves, "Sitting in company, I chanced to take notice, that in ordinary diſcourſe, all that is ſpoke, is ſpoken in perfect notes; and that ſome of the company uſed eighths, ſome fifths, and others thirds. I obſerved likewiſe of him whoſe ſpeech was the moſt pleaſing, that all the tones he uſed, conſiſted either of concords, or of ſuch diſcords as made up harmony."

Cutting the trachea was long reputed mortal; but it is now uſual to open it in dangerous quinſies. This, phyſicians were at firſt encouraged to do, from the caſe of a Corniſh gentleman, who had his wind-pipe quite cut through, and yet was cured and lived ſeveral years after.

38. In order to the admiſſion and expulſion of the air by the lungs, it is neceſſary the breaſt ſhould be contracted and dilated. This end is ſerved by the bony part of the thorax, the intercoſtal muſcles, and the diaphragm,

aphragm, a broad, muſcular part, reaching acroſs the breaſt, and dividing the middle from the lower cavity. It runs obliquely from the ſternon and ribs before, to the vertebræ of the loins behind.

39. The whole thorax is covered on the inſide with a firm, white membrane, called the pleura. It is double throughout, conſiſting of two folds: the innermoſt whereof has a ſmooth ſurface, that it may not hurt the tender ſubſtance of the lungs; the ſurface of the outer is rough and uneven. From the pleura riſes the mediaſtinum, which is a double membrane, that divides the lungs and the cavity of the thorax lengthways into two parts.

40. On the ſlighteſt obſervation we cannot but acknowledge, the conſummate wiſdom wherewith the external parts of the middle cavity are formed, for beauty, as well as for the defence of the internal. This is commodiouſly connected with the head, by the neck. The breaſt, or fore-part of the thorax, which begins at the throat, and ends at the ſternon, or breaſt-bone, is an admirable guard to the nobleſt parts. To the ſame end ſerve the ſhoulder blades and the back-bone, as well as to ſupport the whole fabric.

The breaſts conſiſt of numberleſs oval glands, intermixed with globular veſſels of fat. Their ducts, as they approach the nipple, unite together, till they form eight or more ſmall pipes, communicating with each other by croſs canals, which are of great uſe, when ſome of them happen to be obſtructed. Theſe tubes are in ſome parts narrower, in ſome wider, ſo as to form cells, which hinder the efflux of the milk. The paps conſiſt chiefly of the concurrence of theſe tubes, but with a glandulous ſubſtance intermixed. There are likewiſe joined herewith abundance of fibres, from the external teguments of the breaſts, by means of which the tubes are conſtringed, and the motion of the milk is modified.

In virgins, the glands of the breaſts are ſo contracted, that no blood can enter them. But when the womb ſwells with the fœtus, and compreſſes the deſcending trunk of the great artery, the blood forces

its

its way into them. They admit thicker and thicker ſerum, till after the birth, they run with a thick milk.

It is more difficult to account for the milk which ſome men have in conſiderable plenty. Thus in the year 1684, a countryman, called Billardino di Billo, living in a village near Nocœra, in Umbria, when his wife was dead, took the child, and put the nipples of his breaſts into its mouth, invited it to ſuck; which the infant did, and after ſeveral times drawing, fetched ſome milk. After awhile it brought down the milk ſo plentifully, as to nouriſh it for many months till it was weaned.

Almoſt as ſtrange is the following account: "One informing me of an old woman that gave ſuck, I went to the houſe in Tottenham-court-road. Her name is Elizabeth Bryan. She is in the 68th year of her age, and has not borne a child for many years: her face is withered, her cheeks and mouth ſunk in: but her breaſts are full, fair, and void of wrinkles. About four years ago, her daughter was obliged to leave an infant ſhe gave ſuck to, in the care of her mother. The old woman finding the child froward for want of the breaſt, applied it to her own. Having done this ſeveral times, her ſon thought the child ſeemed to ſwallow, and begged his mother, he might try, if ſhe had not milk? It ſoon appeared ſhe had; and ſhe then continued to ſuckle the child in earneſt. Two years after, her daughter had another child; on which the grand-mother weaned the firſt, and ſuckled the ſecond. Both the children are healthy, plump, and firm in fleſh, and as briſk and lively as can be deſired."

41. In the lower cavity firſt occurs the ſtomach, with the oeſophagus or gullet, which reaches to it from the mouth. The right orifice, called the pylorus, tranſmits the digeſted food to the inteſtines. It is narrower than the other, as being deſigned to tranſmit nothing, till it is reduced to a kind of liquid. And it goes by a long and oblique deſcent into the duodenum, that the chyle may not paſs out, either ſwiftly or too ſlowly.

The

The upper opening of the ſtomach, is compreſſed in ſuch a manner, by the lower muſcle of the diaphragm, in every inſpiration, as to confine the food within the ſtomach, and direct it in every reſpiration, towards the pylorus. By this means this orifice of the ſtomach, is ſo cloſely ſhut, as to confine even wind or vapours within the cavity of a healthy ſtomach, from whence they never eſcape but by a morbid affection.

The fabric of the ſtomach anſwers to that of the oeſophagus, of which it is an expanſion. (1) The outmoſt coat is from the peritoneum, of conſiderable ſtrength, ſo as to limit the extenſion of the reſt, and afford a ſupport to the ſubjacent muſcular fibres. (2) The cellular coat lies immediately under the former, whence the outer and muſcular tunic cloſely cohere together; in this ſubſtance the larger branches of the veſſels are diſtributed. Next in order appears (3) the muſcular coat. Here, the longitudinal fibres of the oeſophagus, coming to the ſtomach are detached one from another in all directions.

Immediately under the muſcular fibres, follows (4) another cellular ſtratum, larger than the outermoſt, ſofter, more eaſily inflatible, and conſiſting of larger veſicles than what we uſually obſerve, even in the inteſtines. Within this cellular ſubſtance are ſpread the ſmall veſſels, which, coming from the larger branches of the ſtomach, enter through its muſcular coat, and ſpread internally after the manner of a plexus. Under this lies, (5) the nervous coat, which is thick, white, and firm, and makes up the true ſubſtance of the ſtomach itſelf, and this is again lined internally with a third cellular ſtratum, whoſe vaſcular net-work is much more minute than that of the former, from whence it is derived. Immediately within this, lies (6) the villous or velvet-like coat, that lines the cavity of the ſtomach itſelf, contiguous with the external cuticle, like which it is renewable, but of a ſoft mucous texture, and extended into a very ſhort pile, like that of the tongue, only leſs conſpicuous, and folded into large plates

42. The

42. The inteſtines are a continuation of the alimentary tube from the pylorus, wound together in various wreaths, yet without confuſion, and to keep them in their ſituation, faſtened together by the meſentery, a ſtrong membrane, which faſtens them alſo to the back. The inteſtinal duct is really but one; but becauſe the parts of it differ in figure and uſe, the upper part of it, divided into the duodenum, jejunum and ileum, is termed the ſmall guts; the lower part, divided into the cœcum, colon and rectum, is called the great guts. All theſe are full of turnings and windings, eſpecially the ſmall, that the more ſubtle part of the chyle, both through the length and narrowneſs of the paſſage, and the agitation of the inteſtines, may enter the lacteal veins, and paſs from thence into the receptacle of the chyle.

When the inteſtines are ſeparated from the meſentery, they are uſually ſix times as long as the man. They have all a kind of vermicular motion, called the periſtaltic motion from the ſtomach downwards; and are lubricated with much fat, eſpecially the great ones, whoſe ſurface being more uneven, and their contents leſs fluid, they need ſomewhat more to make them ſlide eaſily.

Likewiſe from the exhaling arteries diſtils a thin, watry liquor into the cavity of the inteſtines not at all acid, but like the juice of the ſtomach; the quantity of which liquor may be computed from the large extent of all the excretory orifices, and from the ſection of the ſecretory artery, a larger than which, we ſee no where in the body.

The duodenum, (ſo called becauſe it is uſually ten or twelve inches long) receives the gall and pancreatic juice, which are here mixt with the chyle. The jejunum is ſo termed, becauſe it is generally more empty than the reſt. This may be occaſioned partly by its capacity, which gives a free paſſage to its contents; partly to its irritation through the bile, which falls in a little above it. It takes up almoſt the whole umbilical region, and is uſually twelve or thirteen hands long. The ileum, ſituate below the navel, fills the ilia with its numerous convolutions. It is much the longeſt of all the inteſtines, generally one and twenty hands long. In both this and the jejunum the inner coat is much wrinkled,

wrinkled, and lies in looſe folds. They are formed (as the folds in the ſtomach) only by the inner coat being larger than the outer.

The firſt of the great guts, called the cœcum, is literally inſerted at the upper end of the colon. It is not perforated at the other end, but hangs to it, like the finger of a glove, and is three or four inches long. In new-born children, and in beaſts, it is found full of excrements; but in adults it frequently hangs like a worm. In a fœtus it is doubtleſs a receptacle of the fæces, during the time it does not diſcharge by ſtool. And may it not occaſionally ſerve the ſame end in adults? Perhaps in thoſe animals wherein it is very large, it may likewiſe ſerve as a kind of ſecond ſtomach. But it is not abſolutely neceſſary. The cœcum of a dog has been cut out, without any perceivable prejudice.

The colon is the largeſt of the great guts. It runs into various circumvolutions from the cœcum to the rectum. It has many cavities, formed by two ligaments, running on each ſide of it, oppoſite to each other the whole length, and as it were guiding it at certain diſtances. The rectum, which reaches from the os ſacrum to the anus, is uſually about a hand and a half long.

43. The lacteal veins, which are of a whitiſh colour, are in all the inteſtines, ſmall and great, and receive the chyle by imperceptible paſſages, throughout the whole canal. And for this end the food remains ſo long in the inteſtines, and is carried through various windings, that whatſoever of nouriſhment it contains, may be expreſt before it leaves the body.

44. The inteſtines are covered with the omentum or cawl, which is contained within the peritoneum, a very thin, ſoft, double membrane, and wholly conſiſts of little bags of fat. Its uſe is to keep the inteſtines warm; to promote their periſtaltic motion by lubricating them with its oily ſubſtance? by following them in their doublings and windings, to ſerve them as a bolſter to ſlide upon, and by filling up their hollows, to prevent their being too much diſtended by flatulencies; yet giving way to them when filled with aliments.

Under

Under the ſtomach behind lies the pancreas (extended towards the ſpleen) which tranſmits to the inteſtines a liquor of the nature of ſpittle, helping to diſſolve the food.

45. Under the diaphragm, on the right ſide, lies the liver, whence it extends over the right part of the ſtomach, below the ſternum, toward the left, growing gradually ſmaller, that it may not hinder the diſtention of the ſtomach. It conſiſts partly of gall-ducts, partly of fine ramifications of the vena porta. The blood contained in theſe, depoſits oily particles in the ducts, and then returns, chiefly through the vena cava, to the heart. It is thus the bile is ſecreted, for which purpoſe the gall-bladder alſo is deſigned. This both receives and retains the bile, by which delay the power of it is greatly heightened. Part of the bile is conveyed to the inteſtines by the hepatic duct, which pours it into the ductus choledochus. Part goes firſt into the gall-bladder, thence into the ductus choledochus, and then into the duodenum.

The principal uſe of the bile is, to abſterge and ſtimulate the inteſtines, to aſſimilate crude things to things concocted, to bruiſe and blunt ſharp and ſaline particles, to divide thoſe that are coagulated: to excite appetite, to open the paſſages for the chyle, and where need is, act the part of a ferment.

46. The ſpleen is an elegant net-work of numberleſs veſſels, encloſed in a double membrane: it is placed on the left ſide, between the ſhort ribs and the ſtomach. Some ſuppoſe it to ſecrete a peculiar juice, which paſſes with the blood through the vena porta. Others imagine it to be a kind of reſervoir, wherein on extraordinary occaſions, that blood may be received, which would otherwiſe oppreſs the viſcera and diſturb the animal functions.

47. On the muſcles of the loins on each ſide lie the kidneys, to ſeparate from the blood that part of the ſerum which is ſuperfluous, and would be hurtful were it retained in the habit. This is carried by the ureters into the bladder, which is placed in the loweſt part of the

the belly. What remains of the blood is conveyed to the heart by the veins and lymphatic veſſels.

The bladder is compoſed of three coats: the firſt is an extenſion of the peritoneum; the ſecond conſiſts of muſcular fibres; the third is both glandulous and nervous, and full of wrinkles, that it may be capable of contraction and dilation. Its glands ſeparate a ſlimy matter, which defends the bladder from the acrimony of the urine. The involuntary emiſſion of this is prevented, by a ſmall muſcle which goes round the neck of the bladder.

48. We proceed to the limbs. The hand (phyſically ſpeaking) is divided into the arm, the cubit, and the hand, properly ſo called. In this there are twelve bones, beſide fifteen in the fingers, all oblong, ſlender, hollow, and ſo fitly joined together by ligaments, ſo wonderfully provided with various muſcles, adapted to ſo many different motions, that the hand alone gives us an abundant argument of the admirable wiſdom of God.

Is there any poſſibility, that the want of ſo neceſſary an inſtrument as the arm ſhould be ſupplied? One would think it impoſſible. But it is not: ſuch is the amazing power of God! James Walker was born in 1718, in Ireland, in the pariſh of Hillſborough. His mother could not be delivered, till the ſurgeon totally ſeparated the arms of the child from the body. Nevertheleſs he lived, and in the room of his arms, had little protuberances that appeared as ſtumps. He grew to be ſix feet high, ſlender, and active. "He fits a ſaddle, ſays an eye-witneſs, upright and firm, will ride 40 miles a day to a fair, and deals in buying and ſelling horſes, which he dreſſes and curries as well as any groom can do, holding the curry-comb between his chin and ſhoulders. The ſame way he holds the goad in driving the plough, and the ſpade when he digs. He throws a ſtone from the top of his foot with greater force than moſt men can with their hand, and ſeldom fails to hit his mark. He mounts a horſe without any aſſiſtance, and ſhuffling the bridle over his head, till he gets it on his ſhoulders, guiding his horſe with as little fear, and as much ſkill as any man."

49. The

49. The thigh conſiſts of one bone, the largeſt and longeſt in the whole body. It is a little crooked, bending forward before, that there may be more room for the muſcles. The bones of the leg are two, diſtant from each other in the middle, but joined together at each end. They are nearly of the ſame length, but the inner is much thicker than the outer. The bones of the foot are twelve, beſide fourteen in the toes; which like thoſe in the hands, are moſt aptly connected by ligaments, and fitted with muſcles of various kinds, ſerving for equally various motions.

50. Thus far we have ſpoken concerning the ſolid parts of the body. Among the fluid are uſually reckoned the animal ſpirits, ſuppoſed to be ſecreted in the brain, to flow through the nerves, and to be the inſtruments of ſenſe and motion.

"But are the nerves in general hollow canals, which contain a circulating fluid? Or are they ſolid threads, which being highly elaſtic, vibrate variouſly to occaſion various ſenſations?" The latter ſuppoſition is wholly overthrown by the phenomena of wounded nerves. A nerve cut aſunder does not retract its divided extremities, but becomes rather longer, extruding its medulla into a round tubercle. Again, were it elaſtic, it ſhould be compoſed of hard fibres, having their extremities fixt to ſome firm bodies: ſince ſtrings, otherwiſe conſtituted and diſpoſed, have no elaſticity. But it is evident, all nerves are ſoft at their origin, as well as void of tenſion: and ſome ſoft in every part, as the olfactory nerve, and the ſoft portion of the auditory nerve. Yea, they all grow ſoft in the viſcera, the muſcles, and the ſenſories, before they exert their functions. Beſides, ſome nerves are ſo ſituate, that they cannot vibrate, as thoſe of the heart, which are faſtened to the great veſſels and the pericardium. Further, the influence of an irritated nerve is never propagated upwards; whereas an elaſtic chord communicates its tremors to both ends from the point of percuſſion. Hence it is plain, the nerves do not act by their ſpring, but by the motion of their proper fluid. The extreme ſmallneſs of theſe canals, which no microſcope can reach, is no valid objection to this: nei-

ther our inability to diſcern that fluid. This only proves the imperfection of our ſenſes.

"But what is this fluid?" Who can tell? We may very probably conjecture, it conſiſts of ſome ſubtle fire or ether, diffuſed through the whole ſyſtem of nature, and acting by laws unknown to us.

51. Of the other fluids, ſome ſerve to prepare the chyle; ſome to thin the blood and preſerve it from putrefaction. Others only remain till they can be thrown out of the body, as being uſeleſs and ſuperfluous. All of theſe, but the chyle, ariſe from the blood, being ſecreted from it by proper glands. But as to the manner of ſecretion, after all the moſt accurate and laborious inquiries, it ſtill remains abſolutely uncertain; and every one abounds in his own ſenſe. Some believe it depends on the ſuitableneſs of the fluid ſecerned, to the ſhape of the ſecerning pores. Some lay the ſtreſs rather on the various ſize and diameters of thoſe pores: others on this, that the conſtituent particles, ſuppoſe of the bile, from their peculiar proportion, texture and figure, may be more eaſily united to each other, than to the particles of lymph, or any other fluid.

52. The chief of all the fluids in our body, and the fountain of life, is the blood. It conſiſts of a watry ſerum, fibrous particles, and red globules, which laſt are ſcarce a twelfth part of it. It is generated thus. The meat and drink being digeſted into chyle, paſs from the inteſtines, through the lacteal veins and the thoracic duct, into the left ſubclavian vein, and thence into the vena cava, where it mixes with the blood, and then circulates with it, till it is wholly aſſimilated.

Blood, freſh drawn, appears to the naked eye, uniform and homogeneous. But when cold, it ſeparates into two parts; the one red and fibrous, which clots together; the other thin and tranſparent, called the ſerum, in which the former ſwims. The ſerum is in bulk three fourths of the blood; in weight fifteen ſeventeenths.

A red globule is computed to be 25,000 times ſmaller than the ſmalleſt grain of ſand.

But whence ariſes the heat of the blood? This deſerves a particular inquiry.

Fermentation is that ſpontaneous, inteſtine motion, which by the heat of ſubterraneous caverns, will in a few hours ſo change vegetable juices (for fermentation is confined to the vegetable kingdom) as from a vapid wort quenching fire, to nouriſh fire, and to afford that inflammable liquor, commonly called ſpirits.

Efferveſcence ariſes from an inteſtine motion excited in various fluids, by the mixture of other fluids, or of ſalts or powders of a different nature. Acids and alkali, when mixt, cauſe a great ebullition, but no great heat: whereas the ſolution of ſome metals in aqua-fortis, cauſes intenſe heat, and emits flame. Aromatic oils, mixt with acid mineral ſpirits, kindle and burn with violent exploſions.

In theſe caſes, as there is no adventitious fire, there muſt be fire lying hid in one or other of the bodies. And it is known, much air lies dormant in all bodies. It is known likewiſe, that fire cannot exert itſelf, without the help of air. It being granted then, that fire and air lie dormant in all bodies, there is only required ſuch an action as may ſet at liberty the particles of air and of fire. By this action, the particles of air recover their elaſticity, and putting thoſe of fire in motion, cauſe heat, but not incenſion, unleſs this fire meet a proper pabulum, which pabulum is ſulphur only, though differently modified, whether in the appearance of brimſtone, oil, ſpirits, metalline ſulphur, or the moſt inflammable of all, animal ſulphur, commonly called phoſphorus.

In fermentation, the fire and air being let looſe, produce warmth, but ſeldom kindle, becauſe of the water predominating. But in the efferveſcence, produced by the ſolution of metalline ſulphur, they kindle and ſometimes cauſe exploſions. Aromatic oils, containing little but the ſulphureous parts of the vegetables, immediately kindle and break out into flame. And phoſphorus is ſo highly inflammable, that if it be only expoſed to the air a few minutes, it kindles and flames.

Now all animals contain more or leſs phoſphorus. Some inſects conſtantly ſhine in the open air. Many ſorts of fiſh are luminous: ſome quadrupeds emit light,

on a very ſlight friction. Theſe are proofs of phoſphorus lying dormant in animal fluids: and as they all contain air likewiſe, let only the phoſphoreal and æreal particles be brought into contact, and heat neceſſarily enſues.

This clearly explains the cauſe of animal heat: of which the heart and arteries are the occaſion; not by friction, but by the inteſtine motion which the circulation gives to the ſeveral particles that conſtitute the maſs of animal fluids. As the velocity of theſe fluids is increaſed, the particles of which they conſiſt, come oftner into contact, and the oftner the phoſphoreal and æreal meet, the more heat they produce.

But to what cauſe is the colour of the blood owing?—Borelli took ſome of the red part, and waſhing it frequently in water, found it ſeparable into a viſcous ſlippery ſubſtance, conſiſting of colourleſs fibres, which roſe and gathered into a ſcum on the top of the water, and a deep red powder, which precipitated plentifully to the bottom. Hence it appears that the redneſs of the blood ſprings from red tinging particles, as in the caſe of dying.

However, this red colour, though generally found in the blood of land-animals, is not abſolutely neceſſary, there being ſome ſpecies, whoſe blood is white or limpid. Nay Dr. Drake let out of the median vein of a man, a pure, white blood, like milk, which when cold, did not ſeparate into two parts, as the red uſually does. Nor yet did it yield any ſcum or cream, neither turn ſour as milk uſes to do. Dr. Beal gives an inſtance of the ſame kind; and Dr. Lower relates one as ſtrange. A perſon bled at the noſe, till at length the broth he drank flowed out very little altered.

It is amazing to ſee, how careful providence has been, to prevent the blood's running into concretions, which might deſtroy life, by the very diſpoſitions of the veſſels it is to run through. Theſe are ſo contrived, as to cauſe the globules to come together with a briſk colliſion. The arteries which convey the blood from the heart to the extremities, continually leſſen, as they recede from their ſource; in conſequence of which, the globules of blood muſt ruſh with force againſt one another, as they are driven on impetuouſly. And the

veins

veins which bring it back from the extremities to the heart, enlarging all the way as they go on, while the ſtreams of ſeveral continually run into one, each of theſe ingreſſes cauſes new commotions, capable, though not of diſſolving that natural connexion of the red and ſerous particles, yet of preventing any preternatural concretions or coagulations.

53. Theſe are the parts of which this wonderful machine is compoſed, which the chymiſts ſay, conſiſts of four ſorts of matter, earth, water, ſalt, and ſulphur, the particles of which being variouſly mixt together, conſtitute larger particles of different kinds; out of which, more looſely or cloſely connected, all the parts of the body, ſolid or fluid are compoſed.

But this is far from being an accurate account. For what are ſalt and ſulphur but ſpecies of earth? May not we then much more properly ſay with the ancients, that the body is chiefly compoſed of earth and water, yet cannot enjoy even animal life, unleſs air and fire alſo be wrought into its frame? So that at whatſoever time, it is deprived either of air or fire, it is an uſeleſs, lifeleſs clod. And yet the manner how theſe are ſo intimately mixt, both with our fluid and ſolid parts, as much exceeds our comprehenſion, as the manner how the ſoul is united to its houſe of clay.

That much air is wrought into the whole animal frame, appears by the following experiments. The blood of a ſheep, freſh drawn, was in a wide-mouthed glaſs put into a receiver, and the air drawn out. After a while, the ſubtle parts of the blood forced their way through the clammy ones, and ſeemed to boil in large cluſters, ſome as big as nutmegs. And ſometimes the expanſion was ſo vehement, that it boiled over the glaſs.——Some milk being put into a veſſel four or five inches high, when the air was drawn out, it boiled ſo impetuouſly, as to throw up ſeveral parts out of the glaſs that contained it.

And to ſhew, that not only the blood, but the other parts of animals include air; the liver of an eel was put into a receiver, and even this apparently ſwelled every way, as ſoon as the air was withdrawn.

The

The air, as a fixt element in the compoſition of ſolid and fluid bodies, has been generally overlooked by philoſophers, and even by the chymiſts, who have above all ſects, gloried in their knowledge of principles or elements; until Mr. Boyle, Sir Iſaac Newton, and more eſpecially Dr. Hales, by many experiments demonſtrated, that a great part of the ſubſtance of moſt bodies, in ſeveral to half their weight, is a permanent or unelaſtic air, which being freed [either (1) ſlowly, by the air-pump, putrefaction, fermentation, diſtillation, &c. or (2) ſuddenly by exploſions, fulminations, ebullitions, mixtures, &c.] from the other ſolid particles, aſſumes its elaſticity, and fills an immenſe ſpace, in compariſon of the body from whence it came. Dr. Hales found a cubic inch of blood in diſtillation, afforded above 30 times its bulk of elaſtic air; whoſe particles are in effect the wedges of nature which pin and cement together the other elements, and particles of bodies for their growth of accretion; and under other circumſtances, regaining their elaſticity, ſerve to break again thoſe parts for the diſſolution of the compound, whoſe matter may be, by the ſame inſtrument, again differently aſſembled and combined for the forming of other bodies.

54. It remains to add ſome reflections on the wiſdom of God, diſplayed in the ſtructure of the human body. And how eminently is this diſplayed, firſt, in the ſituation of its ſeveral parts and members! They are ſituated moſt conveniently for uſe, for ornament, and for mutual aſſiſtance. 1. For uſe. The principal ſenſes are placed in the head, as ſentinels in a watch-tower. How could the eyes have been more commodiouſly fixt, for the guidance of the whole body? The ears likewiſe, made for the reception of ſounds, which naturally move upward, are rightly placed in the uppermoſt parts of the body: and ſo are the noſtrils, as all odours aſcend. Again: how could the hands have been more conveniently placed, for all ſorts of exerciſes? Or the heart, to diſpenſe life and heat to the whole body? Or the ſinks of the body, than in the moſt remote parts of it? 2. For ornament. Not to deſcend to particulars, what could be better contrived,

than

than that thoſe members which are pairs ſhould be of equal length, and juſt anſwer one another on each ſide? 3. For mutual aſſiſtance. So the eye ſtands moſt conveniently to guide the hand, and the hand to defend the eye. The ſame may be ſaid of the other parts: they are all ſo placed, as to direct or help each other. This will clearly appear, if you ſuppoſe the poſition of any of them to be changed. Had our arms been bent backward, what direction could our eyes have afforded us in working? Or how could we even have fed ourſelves? Nay, had one arm bent backward, and the other forward, half the uſe of them had been loſt; for one could not have aſſiſted the other in any action.

How is his wiſdom diſplayed, Secondly, in the ample proviſion made for the ſecurity of the principal parts! Theſe are, 1. The heart, the fountain of life. This lies in the centre of the trunk of the body, covered with its own membrane; the pericardium, lodged within the ſoft bed of the lungs, encompaſt round with a double fence, both of thick muſcles and ſkins, and of firm ribs and bones; beſides the arms, conveniently placed to ward off any violence: 2. The brain, the principle of all ſenſe and motion, is ſurrounded with ſo ſtrong a defence, that it muſt be a mighty force indeed, which is able to injure it. The ſcull is ſo hard, thick and tough, that it is almoſt as firm as a helmet of iron. This is covered with ſkin and hair, which both keep it warm, and ſoften the violence of a ſtroke. Yet more, a thick and tough membrane hangs looſe about it, which often ſaves it, even when the ſcull is broke. And laſtly, a fine membrane cloſely adheres, to keep it from quaſhing and ſhaking.

How is it diſplayed, thirdly, in the abundant proviſion that is made againſt evil accidents and inconveniencies! To this end, 1. The members which are of eminent uſe are in pairs. We have two eyes, ears, noſtrils, hands; two feet, two breaſts, two kidneys; that if one ſhould be rendered uſeleſs, the other might ſerve us tolerably well: whereas had a man but one hand or eye, if that were gone, all were gone. 2. All the veſſels have many ramifications, which ſend forth twigs to the neighbouring veſſels: ſo that if one branch

be

be cut or obſtructed, its want may be ſupplied by the twigs from the neighbouring veſſels. 3. Many ways are provided to evacuate, whatever might be hurtful to us. If any thing oppreſs the head, it can free itſelf by ſneezing: if the lungs, they can caſt it off by coughing. If any thing burden the ſtomach, it can contract itſelf, and throw it up by vomit. Beſide theſe evacuations, there are ſiege, urine, ſweat, and hæmorhages of various kinds. 4. Whereas ſleep is neceſſary for us in many reſpects, nature has provided, that though we lie long on one ſide, we ſhould feel no uneaſineſs while we ſleep, no, nor when we awake. One would think, the whole weight of the body preſſing the muſcles on which we lie, would be very burdenſome. And we find by experience, ſo it is, when we lie long awake in the night. Probably this proviſion is made, by an inflation of the muſcles, making them ſoft, and yet renitent, like pillows. That they are inflated during ſleep, appears to the very eye, in the faces of children; and from the common experiment, that if we ſleep in our clothes, we muſt looſen our garters and other ligatures, otherwiſe we find uneaſineſs in thoſe parts. 5. Becauſe ſleep is inconſiſtent with the ſenſe of pain, therefore during reſt, thoſe nerves that convey the motions to the brain, which excite the ſenſe of pain are obſtructed. "This I myſelf, ſays Mr. Ray, have often experienced, ſince I have had ſores on my legs. Waking ſuddenly, I find myſelf at perfect eaſe for awhile. Then the pain by degrees returns."

It is diſplayed, fourthly, in the multitude of intentions God hath in the formation of the ſeveral parts, and the multitude of qualifications they require to fit them for their ſeveral uſes. Galen obſerves, "that there are in a human body, above ſix hundred muſcles. And there are at leaſt ten ſeveral intentions in each, and as many qualifications needful: ſo that about the muſcles alone, no leſs than 6000 ends are to be attended to. The bones are reckoned to be 284. The diſtinct intentions in each of theſe are above forty: in all about a hundred thouſand. And thus it is, in proportion, with all the other parts: the ſkin, ligaments, veins, arteries, nerves, glands, humours: but more eſpecially with the members of the body, which as to

the

the multitude of intentions and qualifications, far exceed, the ſimilar parts. And ſhould one of theſe qualifications fail, great inconvenience would enſue."

It is diſplayed, fifthly, in the ſtature of man, ſo admirably well adapted to the circumſtances of his exiſtence. Had man been only a foot or two high, he had been quite diſproportioned to every thing round about him. Had he been much larger, he could not well have been ſupplied with food: all the edible animals would not have ſufficed. And had they too been proportionably larger, the ſurface of the earth would not have ſufficed to feed them.

It is however a common opinion, and has been ſo ever ſince old Homer's time, that the people in the early ages of the world, were much larger than us. And it is true, we read of ſome men of a ſurpriſing ſtature. But they were even then eſteemed giants. The ordinary ſtature of men, is probably juſt the ſame now, as it was in the beginning. This may be gathered from the monuments ſtill remaining, particularly the pyramids of Egypt. The cavities for bodies now viſible herein, are little larger than our ordinary coffins: likewiſe from ſeveral embalmed bodies taken out of them it appears, that men are of the ſame ſtature now, that they were when thoſe pyramids were built, which is at leaſt three thouſand years ago.—— Eighteen hundred years ſince, the Emperor Auguſtus was five feet ſeven inches high: Queen Elizabeth was taller by two inches, being five feet nine.

But what a paradox is it, that all men are taller in the morning than in the evening? In a young man, the difference is near an inch, try the experiment as often as you pleaſe. Does not the difference proceed from hence, that as long as the trunk of the body is in an erect poſture, there is a conſtant preſſure on the large cartilages connecting the vertebræ of the ſpine? So long they gradually contract, and conſequently a man grows ſhorter. But they again gradually expand themſelves, while we are in a reclining poſture.

As to the art of embalming, it appears from a mummy, not long ſince dug up in France, that this was more completely underſtood in the weſtern world ſome

ages ſince, than ever it was in Egypt. This mummy which was dug up at Auvergne, was an amazing inſtance of their ſkill. As ſome peaſants were digging in a field near Rion, within about twenty-ſix paces of the highway, between that and the river Artier, they diſcovered a tomb, that was about a foot and a half beneath the ſurface. It was compoſed only of two ſtones; one of which formed the body of a ſepulchre, and the other the cover.

This tomb was of freeſtone; ſeven feet and a half long, three feet and a half broad, and about three feet high. It was of rude workmanſhip; the cover had been poliſhed, but was without figure or inſcription: within this tomb was placed a leaden coffin, four feet ſeven inches long, fourteen inches broad, and fifteen high. It was oblong, like a box, equally broad at both ends, and covered with a lid that fitted on like a ſnuff-box, without a hinge. Within this coffin was a mummy, in the moſt perfect preſervation. The internal ſides of the coffin were filled with an aromatic ſubſtance, mingled with clay. Round the mummy was wrapped a coarſe cloth; under this were two ſhirts, or ſhrouds, of the moſt exquiſite texture; beneath theſe a bandage, which covered all parts of the body, like an infant in ſwaddling-clothes; under this general bandage there was another, which went particularly round the extremities, the hands and legs; the head was covered with two caps; the feet and hands were without any particular bandages; and the whole body was covered with an aromatic ſubſtance, an inch thick. When theſe were removed, and the body expoſed naked to view, nothing could be more aſtoniſhing than the exact reſemblance it bore to a body that had been dead a day or two before. It appeared well proportioned, except the head was rather large, and the feet ſmall. The ſkin had all the pliancy, and colour of a body lately dead; the viſage, however, was of a browniſh hue. The belly yielded to the touch; all the joints were flexible, except thoſe of the legs and feet; the fingers ſtretched forth of themſelves when bent inwards. The nails ſtill continued perfect; and all the marks of the joints, both in the fingers, the palms of the hands, and the ſoles of the feet, remained perfectly viſible.

viſible. The bones of the arms and legs were ſoft and pliant; thoſe of the ſcull preſerved their rigidity: the hair which only covered the back of the head, was of a cheſnut colour, and about two inches long. The pericranium at top was ſeparated from the ſcull, by an inciſion, in order to the introducing aromatics in the place of the brain, where they were found mixed with clay. The teeth, the tongue, and the ears, were all preſerved in perfect form. The inteſtines were not taken out of the body, but remained pliant and entire, as in a freſh ſubject; and the breaſt was made to riſe and fall like a pair of bellows. The embalming preparation had a very ſtrong and pungent ſmell, which the body preſerved for more than a month after it was expoſed to the air. If one touched either the mummy, or any part of the preparation, the hands ſmelt of it for ſeveral hours after. This mummy, having remained expoſed for ſome months, began to ſuffer ſome mutilations. A part of the ſkin of the forehead was cut off; all its teeth were drawn out, and ſome attempts were made to pull away the tongue. It was therefore put into a glaſs caſe, and tranſmitted to the king's cabinet at Paris.

There are many reaſons to believe this to be the body of a perſon of the higheſt diſtinction; however no marks remain to aſſure us either of the quality of the perſon, or the time of his deceaſe. There are only to be ſeen ſome irregular figures on the coffin: one of which repreſents a kind of ſtar.

There were alſo ſome ſingular characters upon the bandages, which were totally defaced by thoſe who had tore them. It ſhould ſeem that it had remained for ſeveral ages in this ſtate, ſince the firſt years immediately ſucceeding the interment, are uſually thoſe in which the body is moſt liable to decay.

On this remarkable ſubject, I beg leave to add an extract from a late author.

" I always apprehended that human bodies after death, if interred, or expoſed to the air without any preparation to defend them from the attacks of it, would of neceſſity corrupt, become offenſive, and putrify. The art of embalming is very ancient, and was

invented

invented to preſerve them from this inevitable conſequence of death; but that they may remain unputrified for centuries without any ſort of artificial aid, I have ſeen ſo inconteſtibly proved ſince my arrival at Bremen, that I imagine not the ſhadow of doubt can remain about it. Under the cathedral church is a vaulted apartment, ſupported on pillars; it is near ſixty paces long, and half as many broad. The light and air are conſtantly admitted into it by three windows, though it is ſeveral feet beneath the level of the ground. Here are five large oak coffers, rather than coffins, each containing a corpſe. I examined them ſeverally for two hours. The moſt curious and perfect, is that of a woman. Tradition ſays, ſhe was an Engliſh counteſs, who dying here at Bremen, ordered her body to be placed in this vault uninterred, in the apprehenſion that her relations would cauſe it to be brought over to her native country. They ſay it has lain here two hundred and fifty years. Though the muſcular ſkin is totally dried in every part, yet ſo little are the features of the face ſunk or changed, that nothing is more certain than that ſhe was young, and even beautiful. It is a ſmall countenance, round in its contour: the cartilage of the noſe and the noſtrils have undergone no alteration: her teeth are all firm in the ſockets, but the lips are drawn away from over them. The cheeks are ſhrunk in, but yet leſs than I ever remember to have ſeen in embalmed bodies. The hair of her head is at this time more than eighteen inches long, very thick, and ſo faſt, that I heaved the corpſe out of the coffer by it: the colour is a light brown, and I cut off a ſmall lock, which is as freſh and gloſſy as that of a living perſon. That this lady was of high rank ſeems evident from the extreme fineneſs of the linen which covers her body. The landlord of the inn, who was with me, ſaid, he remembered it for forty years paſt, during which time there is not the leaſt perceptible alteration in it.——In another coffer is the body of a workman, who is ſaid to have tumbled off the church, and was killed by the fall. His features evince this moſt forcibly. Extreme agony is marked in them: his mouth is wide open, and his eyelids the ſame; the eyes are dried up. His

breaſt

breaſt is unnaturally diſtended, and his whole frame betrays a violent death.—A little child who died in the ſmall-pox is ſtill more remarkable. The marks of the puſtules, which have broken the ſkin on his hands and head, are very diſcernable; though one ſhould ſuppoſe that a body which died of ſuch a diſtemper, muſt contain in a high degree the ſeeds of putrefaction.—The two other corpſes are not leſs extraordinary. There are in this vault likewiſe turkeys, hawks, weaſels, and other animals, which have been hung up here, from time immemorial, ſome very lately, and are in the moſt complete preſervation: the ſkin, bills, and feathers, are all unaltered. The magiſtrates do not permit that any freſh bodies be brought here. The cauſe of theſe phenomena are doubtleſs the dryneſs of the place where they are laid. It is in vain to ſeek for any other."

A repoſitory of nearly the ſame kind, a late writer informs us, is at a monaſtery, near Palermo, in Sicily. It is a long, ſubterranean gallery, having niches on every ſide, between ſix and ſeven feet high. In each of theſe is a human body ſtanding erect, in its uſual apparel. The face and the hands are uncovered, and preſerve their ſhape, and natural colour, only a little browner. They are faſtened to the wall by the back. Some of them are believed to have been there two or three hundred years.—Suppoſe they could remain there for ever, what would it profit their former inhabitants!

Another traveller gives a fuller account of them.

"This morning we went to ſee a celebrated convent of capuchins, about a mile without the city of Palermo; it contains nothing very remarkable, but the burial-place, which indeed is a great curioſity. This is a vaſt ſubterraneous apartment, divided into large commodious galleries, the walls on each ſide of which are hollowed into a variety of niches, as if intended for a great collection of ſtatues: theſe niches, inſtead of ſtatues, are all filled with dead bodies, ſet upright upon their legs, and fixed by the back to the inſide of a nich. Their number is about three hundred; they

are

are all dreſſed in the clothes they uſually wore, and form a moſt reſpectable and venerable aſſembly. The ſkin and muſcles, by a certain preparation, become as dry and hard as a piece of ſtock-fiſh; and although many of them have been here upwards of two hundred and fifty years, yet none are reduced to ſkeletons; though the muſcles in ſome are more ſhrunk than in others; probably becauſe theſe perſons had been more extenuated at the time of their death.

Here the people of Palermo pay daily viſits to their deceaſed friends, and recal with pleaſure and regret the ſcenes of their paſt life: here they familiarize themſelves with their future ſtate, and chuſe the company they would wiſh to keep in the other world. It is a common thing to make choice of their nich, and to try if their body fits it, that no alterations may be neceſſary after they are dead; and ſometimes by way of voluntary penance, they ſtand for hours in theſe niches.

The bodies of the princes and firſt nobility are lodged in handſome cheſts or trunks, ſome of them richly adorned: theſe are not in the ſhape of coffins, but all of one width, and about a foot and a half, or two feet deep. The keys are kept by the neareſt relations of the family, who ſometimes come and drop a tear over their departed friends.

Theſe viſits muſt prove admirable leſſons of humility; and they are not ſuch objects of horror as one would imagine: they are ſaid, even for ages after death, to retain a ſtrong likeneſs of what they were when alive: ſo that, as ſoon as you have conquered the firſt feelings excited by theſe venerable figures, you only conſider this as a vaſt gallery of original portraits, drawn after the life, by the juſteſt and moſt unprejudiced hand. It muſt be owned, that the colours are rather faded; and the pencil does not appear to have been the moſt flattering in the world: but no matter; it is the pencil of truth, and not of a mercenary, who only wants to pleaſe.

It might alſo be made of very conſiderable uſe to ſociety: theſe dumb orators could give the moſt pathetic lectures upon pride and vanity. Whenever a fellow begins to ſtrut, or to affect the haughty, ſupercilious air, he ſhould be ſent to converſe with his friends in the

the gallery: and if their arguments did not bring him to a proper way of thinking, I would give him up as incorrigible."

I cannot better conclude this chapter than by an extract from the late pious and ingenious Mr. Hervey, which may ſerve for a recapitulation of what has been ſaid, as well as an improvement of it.

"Let us begin with the leſs adorned, but more ſolid parts, thoſe which ſupport, and which contain the reſt. Firſt, you have a ſyſtem of bones, caſt in a variety of moulds, in a variety of ſizes: all ſtrong, that they may bear up the machine, yet light, that they may not weigh us down: bored with an inward cavity to contain the moiſtening marrow, and perforated with fine ducts, to admit the nouriſhing veſſels. Inſenſible themſelves, they are covered with a membrane, exquiſitely ſenſible, which warns them of, and ſecures them from the annoyance of any hurtful friction; and alſo preſerves the muſcles from being fretted in their action, by the hard and rough ſubſtance of the bone. They are larger at the extremities, that they may be joined more firmly, and not ſo eaſily diſlocated. The manner of their articulation is truly admirable, and remarkably various: yet never varied without demonſtrating ſome wiſe deſign, and anſwering ſome valuable end. Frequently when two are united, the one is nicely rounded and capped with a ſmooth ſubſtance; the other is ſcooped into a hollow of the ſame dimenſions to receive it. And both are lubricated with an unctuous fluid, to facilitate the rotation.

The feet compoſe the firmeſt pedeſtal, infinitely beyond all that ſtatuary can accompliſh, capable of altering its form, and extending its ſize, as different circumſtances require. They likewiſe contain a ſet of the niceſt ſprings, which help to place the body in a variety of attitudes, and qualify it for the multiplicity of motions. The undermoſt part of the heel, and the extremity of the ſole, are ſhod with a tough inſenſible ſubſtance: a kind of natural ſandal, which never wears out, never wants repair: and which prevents an undue compreſſion of the veſſels by the weight of the body.

The

The legs and thighs are like ſtately columns, ſo articulated that they are commodious for walking, and yet do not obſtruct the eaſy poſture of ſitting. The legs ſwell out towards the top with a genteel projection, and are neatly wrought off toward the bottom: a variation which leſſens their bulk, while it increaſes their beauty.

The ribs, turned into a regular arch, are gently moveable, for the act of reſpiration. They form a ſafe lodgement for the lungs and heart, ſome of the moſt important organs of life. The back-bone is deſigned, not only to ſtrengthen the body, and ſuſtain its moſt capacious ſtore-rooms, but alſo to bring down the continuation of the brain, uſually termed the ſpinal marrow. It both conveys and guards this ſilver cord, as Solomon terms it, and by commodious outlets tranſmits it to all parts. Had it been only ſtraight and hollow, it might have ſerved theſe purpoſes. But then the loins muſt have been inflexible: to avoid which, it conſiſts of very ſhort bones, knit together by cartilages. This peculiarity of ſtructure gives it the pliancy of an ozier, with the firmneſs of an oak. By this means it is capable of various inflections, without bruiſing the ſoft marrow, or diminiſhing that ſtrength which is neceſſary to ſupport all the upper ſtories. Such a formation in any other of the ſolids, muſt have occaſioned great inconvenience. Here it is unſpeakably uſeful, a maſter-piece of creating ſkill.

The arms are exactly proportioned to each other, to preſerve the equilibrium of the ſtructure. Theſe being the guards that defend, and the miniſters that ſerve the whole body, are fitted for the moſt diverſified and extenſive operations: firm with bone, yet not weighty with fleſh, and capable of performing all uſeful motions. They bend inwards and turn outwards: they move upward or downward. They wheel about in whatever direction we pleaſe. To theſe are added the hands, terminated by the fingers, not of the ſame length, nor of equal bigneſs, but in both reſpects different, which gives the more beauty, and far greater uſefulneſs. Were they all fleſh, they would be weak: were they one entire bone, they would be utterly inflexible: but conſiſting of various little bones and muſ-

cles,

cles, what ſhape can they not aſſume? Being placed at the end of the arm the ſphere of their action is exceedingly enlarged. Their extremities are an aſſemblage of fine tendinous fibres, accutely ſenſible: which notwithſtanding are deſtined to almoſt inceſſant employ, and frequently among rugged objects. For this reaſon they are overlaid with nails, which preſerve them from any painful impreſſions.

In the hand we have a caſe of the fineſt inſtruments. To theſe we owe thoſe beautiful ſtatues, this melodious trumpet. By the ſtrength of the hand the talleſt firs fall, and the largeſt oaks deſcend from the mountains. Faſhioned by the hand they are a floating warehouſe, and carry the productions of art and nature from Britain to Japan.

The hand is the original and univerſal ſceptre, which not only repreſents, but aſcertains our dominion over all the elements, and over every creature. Though we have not the ſtrength of the horſe, the ſwiftneſs of the greyhound, or the quick ſcent of the ſpaniel, yet directed by the underſtanding, and enabled by the hand, we can as it were make them all our own. Theſe ſhort hands have found a way to penetrate the bowels of the earth, to touch the bottom of the ſea. Theſe feeble hands can manage the wings of the wind, arm themſelves with the violence of fire, and preſs into their ſervice the forcible impetuoſity of water. How greatly then are we indebted to our wiſe Creator, for this diſtinguiſhing, this invaluable member?

Above all is the head, for the reſidence of the brain; ample to receive, and firm to defend it. It has a communication with all, even the remoteſt parts: has outlets, for diſpatching couriers to all quarters, and avenues for receiving ſpeedy intelligence, on all needful occaſions. It has lodgments wherein to poſt centinels, for various offices: to expedite whoſe operations the whole turns on a curious pivot, nicely contrived to afford the largeſt and freeſt circumvolutions.

This is ſcreened from heat, defended from cold, and at the ſame time beautified by the hair: a decoration ſo delicate, as no art can ſupply; ſo perfectly light, as no way to encumber the wearer.

While

While other animals are prone in their aſpect, the attitude of man is erect, which is by far the moſt graceful, and beſpeaks ſuperiority. It is by far the moſt commodious, for proſecution of all our extenſive deſigns. It is likewiſe ſafeſt, leſs expoſed to dangers, and better contrived to repel or avoid them. Does it not alſo remind us of our noble original, and our ſublime end? Our original, which was the breath of the Almighty: our end, which was the enjoyment of him in glory?

This much for the rafters and beams of the houſe. Let us now ſurvey the lodgings within. Here are ligaments, a tough and ſtrong arrangement of fibres, to unite the ſeveral parts, and render what would otherwiſe be an unwieldy jumble, a well compacted and ſelf-manageable ſyſtem: membranes, thin and flexible tunicles, to enwrap the fleſhy parts, to connect ſome, and form a ſeparation between others: arteries, the rivers of our little world, that ſtriking out as they go, into numberleſs ſmall canals, viſit every ſtreet, yea every apartment in the vital city. Theſe being wide at firſt, and growing narrower and narrower, check the rapidity of the blood. This thrown from the heart, dilates the arteries, and their own elaſtic force contracts them: by which means they vibrate againſt the finger, and much aſſiſt both in the diſcovery and cure of diſeaſes. The larger arteries, wherever the blood is forced to bend, are ſituate on the bending ſide: leſt being ſtretched to an improper length, the circulation ſhould be retarded. They are not, like ſeveral of the veins, near the ſurface, but placed at a proper depth. And hereby they are more ſecure from external injuries. In thoſe parts which are moſt liable to preſſure, an admirable expedient takes place. The arteries inoſculate with each other: breaking into a new track, they fetch a little circuit, and afterwards return into the main road. So that if any thing block up or ſtraiten the direct paſſage, the current, by diverting to this new channel, eludes the impediment, flows on, and ſoon regains its wonted courſe.

The veins receive the blood from the arteries, and re-convey it to the heart. The preſſure of the blood is not near ſo forcible in theſe as in the arteries. Therefore

fore their texture is conſiderably ſlighter. Such an exact œconomiſt is nature, amidſt all her liberality! In many of theſe canals, the current, though widening continually, is obliged to puſh its way againſt the perpendicular: hereby it is expoſed to the danger of falling back and over-loading the veſſels. To prevent this, valves are interpoſed at proper diſtances, which are no hinderance to the regular paſſage, but prevent the reflux, and facilitate the paſſage of the blood to the grand receptacle. But theſe valves are only where the blood is conſtrained to climb: where the aſcent ceaſes, they ceaſe alſo.

Here are glands to filtrate the paſſing fluids: each of which is an aſſemblage of veſſels, complicated with ſeeming confuſion, but with perfect regularity. Each forms a ſecretion far more curious than the moſt admired operations of chymiſtry: muſcles, compoſed of the fineſt fibres, yet endued with incredible ſtrength, faſhioned after a variety of patterns, but all in the higheſt taſte for elegance and conveniency. Theſe are the inſtruments of motion, and at the command of the will, execute their functions quick as lightning: nerves ſurpriſingly minute, which ſet the muſcles at work, diffuſe the power of ſenſation through the body, and upon any impreſſion from without, give all needful intelligence to the ſoul: veſicles, deſtined with an unctuous matter, in ſome places compoſe a ſoft cuſhion; as in the calf of the leg, whoſe large muſcles, mixt with fat are of ſingular ſervice to thoſe important bones. This flanks and fortifies them, like a ſtrong baſtion, ſupports and cheriſhes them, like a ſoft pillow. In other places they fill up the vacuities, and ſmooth the inequalities of the fleſh. Inwardly, they ſupply the machine for motion; outwardly, they render it ſmooth and graceful.

The ſkin, like a curious ſurtout, covers the whole, formed of the moſt delicate net-work, whoſe meſhes are minute, and whoſe threads are multiplied, even to a prodigy: the meſhes are ſo minute, that nothing paſſes them, which is diſcernable by the eye; though they diſcharge, every moment, myriads and myriads of ſuperfluous encumbrances. The threads are ſo multiplied, that neither the point of the ſmalleſt needle,

dle, nor the infinitely finer lance of a gnat, can pierce any part, without drawing blood, and cauſing an uneaſy ſenſation. Conſequently, without wounding, by ſo ſmall a puncture, both a nerve and a vein!

But a courſe of inceſſant action muſt exhauſt the ſolids and waſte the fluids, and unleſs both are properly recruited, in a ſhort time deſtroy the machine. For this reaſon it is furniſhed with the organs, and endued with the powers of nutrition: teeth, the foremoſt, thin and ſharp, to bite aſunder the food; the hindermoſt, broad and ſtrong, indented with ſmall cavities, the better to grind in pieces what is tranſmitted to them. But in children, the formation of teeth is poſtponed till they have occaſion for them.

Were the teeth, like other bones, covered with the perioſteum, chewing would give much pain. Were they quite naked, they would ſoon decay and periſh. To guard againſt both, they are overlaid with a neat enamel, harder than the bone itſelf, which gives no pain in chewing, and yet ſecures them from various injuries.

The lips prevent the food from ſlipping out of the mouth, and aſſiſted by the tongue, return it to the grinders. While they do this in concert with the cheeks, they ſqueeze a thin liquor from the adjacent glands. This moiſtens the food and prepares it for digeſtion. When the mouth is inactive theſe are nearly cloſed: but when we ſpeak or eat, their moiſture being then neceſſary, is expreſt as needs require.

But the food could not deſcend merely by its own weight, through a narrow and clammy paſſage into the ſtomach. Therefore to effect this, muſcles both ſtraight and circular are provided. The former enlarge the cavity, and give an eaſy admittance. The latter, cloſing behind the deſcending aliment, preſs it downward. But before the food enters the gullet, it muſt of neceſſity paſs over the orifice of the windpipe: whence it is in danger of falling upon the lungs, which might occaſion inſtant death. To obviate this, a moveable lid is placed, which when the ſmalleſt particle advances, is pulled down and ſhut cloſe, but as ſoon as it is ſwallowed, is let looſe and ſtands open. Thus the important paſs is always made ſure againſt

any noxious approaches; yet always left free for the air, and open for reſpiration.

The food deſcending into the ſtomach, is not yet ready for the bowels. Therefore that great receiver is ſtrong to bear, and proper to detain it, till it is wrought into the ſmootheſt pulp imaginable. From hence it is diſcharged by a gentle force, and paſſes gradually into the inteſtines.

Near the entrance waits the gall-bladder, ready to pour its ſalutary juice upon the aliment, which diſſolves any thing viſcid, ſcours the inteſtines, and keeps all the fine apertures clear. This bag, as the ſtomach fills, is preſt thereby, and then only diſcharges its contents. It is alſo furniſhed with a valve of a very peculiar nature, namely, of a ſpiral form; through which the deterſive liquid cannot haſtily pour, but muſt gently ooze. Admirable conſtruction! which without any care of ours, gives the needful ſupply, and no more.

The nutriment then purſues its way through the mazes of the inteſtines: which by a worm-like motion protrude it and force its ſmall particles into the lacteal veſſels. Theſe are a ſeries of the fineſt ſtrainers, ranged into countleſs multitudes all along the ſides of the winding paſſage. Had this been ſtrait or ſhort, the food could not have reſigned a ſufficient quantity of its nouriſhing particles. Therefore it is artfully convolved, and greatly extended, that whatever paſſes may be ſifted thoroughly. As the aliment proceeds, it is more and more drained of its nutritious juices. In conſequence of this, it would become hard, and pain the tender parts, but that glands are poſted in proper places, to diſcharge a lubricated fluid. Theſe are ſmaller or fewer, near the ſtomach, becauſe there the aliment is moiſt enough: whereas in the bowels, remote from the ſtomach, they are either multiplied or enlarged.

The chyle drawn off by the lacteals is carried through millions of ducts, too fine even for the microſcope to diſcover. To this it is owing, that nothing enters the blood, but what is capable of paſſing through the fineſt veſſels. It is then lodged in ſeveral commodious cells (the glands of the meſentery) and there mixt with a thin diluting lymph, which makes it more apt to flow.

Hence

Hence it is conveyed to the common receptacle, and mounts through a perpendicular tube into the left ſubclavian vein. This tube lies contiguous to the great artery, whoſe ſtrong pulſation drives on the fluid, and enables it to aſcend and unload its treaſure, at the very door of the heart.

But the chyle is as yet in too crude a ſtate, to be fit for the animal functions. Therefore it is thrown into the lungs. In the ſpungy cells of this amazing laboratory, it mixes with the external air, and its whole ſubſtance is made more ſmooth and uniform. Thus improved it enters the left ventricle of the heart, a ſtrong, active, indefatigable muſcle. The large muſcles of the arm or of the thigh are ſoon wearied: a day's labour, or a day's journey, exhauſts their ſtrength. But the heart toils whole weeks, whole months, nay years, unwearied: is equally a ſtranger to intermiſſion and fatigue. Impelled by this, part of the blood ſhoots upward to the head; part rolls through the whole body.

But how ſhall a ſtream divided into myriads of channels, be brought back to its ſource? Should any portion of it be unable to return, putrefaction, if not death, muſt enſue. Therefore the all-wiſe Creator has connected the extremities of the arteries, with the beginning of the veins: ſo that the ſame force which darts the blood through the former, helps to drive it through the latter. Thus it is re-conducted to the great ciſtern, and there played off afreſh.

Where two oppoſite currents would be in danger of claſhing, where the ſtreams from the vena cava and vena aſcendens coincide, a fibrous excreſcence interpoſes, which like a projecting pier, breaks the ſtroke of each, and throws both into their proper receptacle. Where the motion is to be ſpeedy, the channels either forbear to wind (as in the great artery, which deſcends to the feet) or to leſſen in their dimenſions, as in every interval between all the ramifications. When the progreſs is to be retarded, the tubes are variouſly convolved, or their diameter contracted. Thus guarded, the living flood never diſcontinues its courſe, but night and day, whether we ſleep or wake, ſtill perſe-

veres

veres to run briſkly through the arteries, and return ſoftly through the veins.

But farther. The great Creator has made us an invaluable preſent of the ſenſes, to be the inlets of innumerable pleaſures, and the means of the moſt valuable advantages.

The eye, in its elevated ſtation, commands the moſt enlarged proſpects. Conſiſting only of fluids, encloſed within coats, it ſhews us all the graces and glories of nature. How wonderful, that an image of the hugeſt mountains, and the wideſt landſcapes ſhould enter into the ſmall pupil! that the rays of light ſhould paint on the optic nerve, paint in an inſtant of time, paint in their trueſt colours and exacteſt lineaments, every ſpecies of external objects!

The eye is ſo tender, that the ſlighteſt touch might injure its delicate frame. It is guarded therefore with peculiar care, intrenched deep, and barricaded round with bones. As the ſmalleſt fly might incommode its poliſhed ſurface, it is farther protected by two ſubſtantial curtains. In ſleep, when there is no occaſion for the ſenſe, but a neceſſity to guard the organ, theſe curtains cloſe of their own accord. At any time they fly together as quick as thought. They are lined with an extremely fine ſponge, moiſt with its own dew. Its briſly paliſades keep out the leaſt mote, and moderate the too ſtrong impreſſions of the light.

As in our waking hours we have almoſt inceſſant need for theſe little orbs, they run upon the fineſt caſtors, rolling every way with the utmoſt eaſe; which circumſtance, added to the flexibility of the neck, renders our two eyes as uſeful as a thouſand.

The ear conſiſts of an outward porch and inner rooms. The porch ſomewhat prominent from the head, is of a cartilaginous ſubſtance, covered with tight membranes and wrought into ſinuous cavities. Theſe, like circling hills, collect the wandering undulations of the air, and tranſmit them with a vigorous impulſe, to the finely ſtretched membrane of the drum. This is expanded upon a circle of bones, over a poliſhed, reverberating cavity. It is furniſhed with braces that ſtrain or relax, as the ſound is faint or ſtrong. The hammer and the anvil, the winding labyrinth, and

the

the ſounding galleries, theſe and other pieces of mechaniſm, all inſtrumental to hearing, are inexpreſſibly curious.

Amazingly exact muſt be the tenſion of the auditory nerves, ſince they anſwer the ſmalleſt tremors of the atmoſphere, and diſtinguiſh their moſt ſubtle variations. Theſe living chords, turned by an Almighty hand, and ſpread through the echoing iſles, receive all the impreſſions of ſound, and propagate them to the brain. Theſe give exiſtence to the charms of muſic, and the ſtill nobler charms of diſcourſe.

The eye is uſeleſs amidſt the gloom of night. But the ear hears through the darkeſt medium. The eye is on duty only in our waking hours: but the ear is always acceſſible.

As there are concuſſions of the air, which are diſcernable only by the inſtruments of hearing, ſo there are odoriferous particles wafted in the air, which are perceivable only by the ſmell. The noſtrils are wide at the bottom, that more effluvia may enter, narrow at the top, that when entered, they may act more ſtrongly. The ſteams that exhale from fragrant bodies, are fine beyond imagination. Microſcopes that ſhew thouſands of animals in a drop of water, cannot bring one of theſe to our ſight. Yet ſo judiciouſly are the olfactory nets ſet, that they catch the vaniſhing fugitives. They imbibe all the roaming perfumes of Spring, and make us banquet even on the inviſible dainties of nature.

Another capacity for pleaſure our bountiful Creator has beſtowed, by granting us the powers of taſte. This is circumſtanced in a manner ſo benign and wiſe, as to be a ſtanding plea for temperance, which ſets the fineſt edge on the taſte, and adds the moſt poignant reliſh to its enjoyments.

And theſe ſenſes are not only ſo many ſources of delight, but a joint ſecurity to our health. They are the inſpectors that examine our food, and inquire into the properties of it. For the diſcharge of this office they are excellently qualified, and moſt commodiouſly ſituated. So that nothing can gain admiſſion, till it has paſt their ſcrutiny.

To

To all theſe, as a moſt neceſſary ſupplement, is added the ſenſe of feeling. And how happily is it tempered between the two extremes; neither too acute, nor too obtuſe! Indeed all the ſenſes are exactly adapted to the exigencies of our preſent ſtate. Were they ſtrained much higher, they would be avenues of anguiſh; were they much more relaxed, they would be well nigh uſeleſs.

The crowning gift, which augments the benefits accruing from all the ſenſes, is ſpeech. Speech makes me a gainer by the eyes and ears of others; by their ideas and obſervations. And what an admirable inſtrument for articulating the voice, and modifying it into ſpeech, is the tongue? This little collection of muſcular fibres under the direction of the Creator, is the artificer of our words. By this we communicate the ſecrets of our breaſts, and make our very thoughts audible. This likewiſe is the efficient cauſe of muſic; it is ſoft as the lute, or ſhrill as the trumpet. As the tongue requires an eaſy play, it is lodged in an ample cavity. It moves under a concave roof, which gives additional vigour to the voice, as the ſhell of a violin to the ſound of the ſtrings.

Wonderfully wiſe is the regulation of voluntary and involuntary motions. The will in ſome caſes has no power: in others ſhe is an abſolute ſovereign. If ſhe commands, the arm is ſtretched, the hand is cloſed. How eaſily, how punctually are her orders obeyed!—To turn the ſcrew, or work the lever, is laborious and weariſome. But we work the vertebræ of the neck, with all their appendant chambers; we advance the leg, with the whole incumbent body: we riſe, we ſpring from the ground, and though ſo great a weight is raiſed, we meet with no difficulty or fatigue.

That all this ſhould be effected without any toil, by a bare act of the will, is very ſurpriſing. But that it ſhould be done, even while we are entirely ignorant of the manner in which it is performed, is moſt aſtoniſhing! Who can play a ſingle tune upon the ſpinnet, without learning the difference of the keys? Yet the mind touches every ſpring of the human machine, with the moſt maſterly ſkill, though ſhe knows nothing at

the ſounding galleries, theſe and other pieces of mechaniſm, all inſtrumental to hearing, are inexpreſſibly curious.

Amazingly exact muſt be the tenſion of the auditory nerves, ſince they anſwer the ſmalleſt tremors of the atmoſphere, and diſtinguiſh their moſt ſubtle variations. Theſe living chords, turned by an Almighty hand, and ſpread through the echoing iſles, receive all the impreſſions of ſound, and propagate them to the brain. Theſe give exiſtence to the charms of muſic, and the ſtill nobler charms of diſcourſe.

The eye is uſeleſs amidſt the gloom of night. But the ear hears through the darkeſt medium. The eye is on duty only in our waking hours: but the ear is always acceſſible.

As there are concuſſions of the air, which are diſcernable only by the inſtruments of hearing, ſo there are odoriferous particles wafted in the air, which are perceivable only by the ſmell. The noſtrils are wide at the bottom, that more effluvia may enter, narrow at the top, that when entered, they may act more ſtrongly. The ſteams that exhale from fragrant bodies, are fine beyond imagination. Microſcopes that ſhew thouſands of animals in a drop of water, cannot bring one of theſe to our ſight. Yet ſo judiciouſly are the olfactory nets ſet, that they catch the vaniſhing fugitives. They imbibe all the roaming perfumes of Spring, and make us banquet even on the inviſible dainties of nature.

Another capacity for pleaſure our bountiful Creator has beſtowed, by granting us the powers of taſte. This is circumſtanced in a manner ſo benign and wiſe, as to be a ſtanding plea for temperance, which ſets the fineſt edge on the taſte, and adds the moſt poignant reliſh to its enjoyments.

And theſe ſenſes are not only ſo many ſources of delight, but a joint ſecurity to our health. They are the inſpectors that examine our food, and inquire into the properties of it. For the diſcharge of this office they are excellently qualified, and moſt commodiouſly ſituated. So that nothing can gain admiſſion, till it has paſt their ſcrutiny.

To

To all theſe, as a moſt neceſſary ſupplement, is added the ſenſe of feeling. And how happily is it tempered between the two extremes; neither too acute, nor too obtuſe! Indeed all the ſenſes are exactly adapted to the exigencies of our preſent ſtate. Were they ſtrained much higher, they would be avenues of anguiſh; were they much more relaxed, they would be well nigh uſeleſs.

The crowning gift, which augments the benefits accruing from all the ſenſes, is ſpeech. Speech makes me a gainer by the eyes and ears of others; by their ideas and obſervations. And what an admirable inſtrument for articulating the voice, and modifying it into ſpeech, is the tongue? This little collection of muſcular fibres under the direction of the Creator, is the artificer of our words. By this we communicate the ſecrets of our breaſts, and make our very thoughts audible. This likewiſe is the efficient cauſe of muſic; it is ſoft as the lute, or ſhrill as the trumpet. As the tongue requires an eaſy play, it is lodged in an ample cavity. It moves under a concave roof, which gives additional vigour to the voice, as the ſhell of a violin to the ſound of the ſtrings.

Wonderfully wiſe is the regulation of voluntary and involuntary motions. The will in ſome caſes has no power: in others ſhe is an abſolute ſovereign. If ſhe commands, the arm is ſtretched, the hand is cloſed. How eaſily, how punctually are her orders obeyed!—To turn the ſcrew, or work the lever, is laborious and weariſome. But we work the vertebræ of the neck, with all their appendant chambers; we advance the leg, with the whole incumbent body: we riſe, we ſpring from the ground, and though ſo great a weight is raiſed, we meet with no difficulty or fatigue.

That all this ſhould be effected without any toil, by a bare act of the will, is very ſurpriſing. But that it ſhould be done, even while we are entirely ignorant of the manner in which it is performed, is moſt aſtoniſhing! Who can play a ſingle tune upon the ſpinnet, without learning the difference of the keys? Yet the mind touches every ſpring of the human machine, with the moſt maſterly ſkill, though ſhe knows nothing at

all of the nature of her inſtrument, or the proceſs of her operations.

The eye of a ruſtic, who has no notion of optics, or any of its laws, ſhall lengthen and ſhorten its axis, dilate and contract its pupil, without the leaſt heſitation, and with the utmoſt propriety: exactly adapting itſelf to the particular diſtance of objects, and the different degrees of light. By this means it performs ſome of the moſt curious experiments in the Newtonian philoſophy, without the leaſt knowledge of the ſcience, or conſciouſneſs of its own dexterity!

Which ſhall we admire moſt, the multitude of organs; their finiſhed form and faultleſs order; or the power which the ſoul exerciſes over them? Ten thouſand reins are put into her hands: and ſhe manages all, conducts all, without the leaſt perplexity or irregularity. Rather with a promptitude, a conſiſtency and ſpeed, that nothing elſe can equal!

So fearfully and wonderfully are we made! Made of ſuch complicated parts, each ſo nicely faſhioned, and all ſo exactly arranged; every one executing ſuch curious functions, and many of them operating in ſo myſterious a manner! And ſince health depends on ſuch a numerous aſſemblage of moving organs; ſince a ſingle ſecretion ſtopped may ſpoil the temperature of the fluid, a ſingle wheel clogged may put an end to the ſolids; with what holy fear, ſhould we paſs the time of our ſojourning here below! Truſting for continual preſervation, not merely to our own care, but to the Almighty hand, which formed the admirable machine, directs its agency, and ſupports its being!

CHAP.

CHAP. II.

Of the Natural State of the Human Body.

1. *What the Natural State of the Body means.*
2. *Of the Circulation of the Blood.*
3. *Of Reſpiration.*
4. *Of Chylification.*
5. *Of Nutrition.*
6. *Of the Senſes.*
7. *Of Sight.*
8. *Of Hearing.*
9. *Of Smelling.*
10. *Of Taſting.*
11. *Of Feeling.*
12. *Of Hunger and Thirſt.*
13. *Of Sleep.*
14. *Of Local Motion.*
15. *Of voluntary and involuntary Motions.*
16. *Of the Stature of Man.*
17. *Of the Age of Man.*

1. THAT is the natural ſtate of the human body, wherein all parts of it duly perform their natural operations. The chief of theſe are, the circulation of the blood, reſpiration, chylification, nutrition, and motion.

2. That the blood circulates through the whole body appears hence. Any of the arteries being tied with a thread, will ſwell and beat between the bandage and the heart, but grow flaccid between the bandage and the extremities of the body. And if the artery be cut between the bandage and the heart, blood ſtreams out, even to death: but if it be cut between the bandage and extremities, very little blood comes out. The vital blood therefore flows from the heart, through the arteries, toward the extremities of the body, and ſtill out of a wider part into a narrower, out of the trunk into the branches.

Any of the larger veins being tied with a thread, ſwells between the extremities and the bandage, but grows flaccid between the bandage and the heart. If opened in the former part, it bleeds largely: if in the latter, ſcarce at all. The blood therefore flows from all the extremes, through the veins into the heart, and ſtill from the narrower parts of the vein to the larger, from the branches to the trunk.

Upon the whole it is evident, that all the arteries are continually bringing the blood from the left ventricle of the heart, through the trunks of the arteries into their branches, and from thence to all parts of the body: and on the contrary, that all the veins, (except the vena portæ) are continually bringing it back from all parts of the body, through the ſmall branches into the larger, and thence through the trunks and vena cava into the right ventricle of the heart. So that the whole blood paſſes through the heart once in five or ſix minutes.

It is certain, that all the arteries and veins communicate or open one into the other; becauſe, often from one, and that a ſmall artery, all the blood ſhall run even unto death, not only out of the wounded limb, but from the whole body. Of ſuch fatal examples we have a number; from an inward artery of the noſe, from the gums, a finger, a tooth, a cutaneous pore enlarged, from the lachrymal point, from the wound of cupping on the ſkin, and even the bite of a leach. There are, therefore, of courſe, open ways by which the blood ſpeedily flows from the venal, into the arterial ſyſtem, and the reverſe.

Late writers have purſued the globules of blood to a great length, and found ſeveral orders of them. The large ones viſible to the naked eye, are globules of the firſt order. Each of theſe is compoſed of ſix ſmaller, joined together in a very regular way. But ſometimes a red globule is ſeen looſening, and breaking into theſe compounding ſpherules. And ſometimes one may perceive theſe running together, and beginning the compoſition of a new, red globule. Theſe ſmaller ſpherules they call globules of the ſecond order. But we are not to ſtop here. There are in the blood a great many particles ſix times leſs than theſe.

Globules

Globules of the ſecond order are compounded of theſe ſmaller ones, which therefore are globules of the third order.

Farther. There are innumerable blood veſſels of ſuch ſmallneſs, that none of the above-mentioned globules can paſs them: ſo that we cannot but ſuppoſe ſtill ſmaller globules. The diameter of ſome veſſels, is leſs than the eighth part of the diameter of a red globule: ſo that the particles paſſing through them, muſt be above five hundred times leſs than thoſe globules. Nay, on a careful examination, we perceive veſſels narrower, than the tenth part of the diameter of a red globule: which conſequently can tranſmit ſpherules no greater, than the thouſandth part of a red globule.

On the whole then, each globule of the firſt order is made up of ſix of the ſecond: theſe of ſix of the third, theſe of ſix of the fourth; theſe of ſix of the fifth, and ſo on. And accordingly we find, the globules of the higheſt orders, may be broken down into their compounding particles.

The diameter of a common red globule is about the 1938th part of an inch. The diameter of a globule of the tenth order, is leſs than the 400,000th part of an inch.

Anatomiſts and phyſicians have generally determined the quantity of blood in the human body, to be between fifteen and twenty-five pounds. But Dr. Keil ſhews from many inſtances of profuſe hæmorrhages, that a far greater quantity muſt be allowed. Otherwiſe the patient could never have furniſhed, or at leaſt, ſurvived ſuch evacuations; the leaſt of which exceeded the whole quantity of blood, ſuppoſed to be in the body.

25.15

In reality, the quantity of blood in a human body, is difficult to be determined. Bleeding to death, the uſual method, can never ſhew what is its true quantity: becauſe no animal can bleed longer, than while the great artery is full; which will require a longer or a ſhorter time, as the wounded artery is ſmaller or greater. And the great artery, muſt always be the firſt veſſel that empties.

The

The only certain way of calculating is, to find what proportion the cavities of the veſſels, of which the whole body is compoſed, bear to the thickneſs of the coats. This in the veins and arteries may be exactly found. But in the other veſſels we only know the quantity of fluid they contain, by carefully evaporating as much as poſſible. Thus the Doctor found the fluids to be in the arteries as 17 to 1; in the veins as 156 to 1: in the bones as 1 to 1. The leaſt of theſe proportions ſhews the liquors to be one half of the weight of the body. And if a calculation be made, on the proportion of the blood in the arteries, alſo to their coats in a body weighing 160 pounds, there will be found 100 pounds of blood or circulating fluid.

In a fœtus the circulation is performed in a peculiar manner. The ſeptum, which ſeparates the two ventricles of the heart is pierced through with an aperture, called the foramen ovale, and the pulmonary artery, a little after it has left the heart, ſends out a tube into the deſcending aorta, called the communicating canal. When the fœtus is born, the foramen ovale cloſes, and that canal dries up into a ſimple ligament.

The fœtus while in the womb receives little air. Its lungs therefore cannot ſwell and ſubſide. They continue almoſt at reſt: nor can they allow the blood to circulate, either in abundance, or with eaſe. Nature therefore has excuſed them from the paſſage of the greateſt part of the blood, and has contrived the foramen ovale, by which, part of the blood of the vena cava paſſes through the right ventricle into the left. And by this means it is found as far on its journey, as if it had paſſed the lungs. But this is not all. For that blood of the cava, which miſſing the foramen ovale, paſſes from the right auricle into the right ventricle, being ſtill too much to paſs by the lungs, the communicant canal intercepts part of it, and pours it immediately into the deſcending aorta.

3. Reſpiration is performed by receiving the air into the lungs, and breathing it out alternately. In the former, the cavity of the breaſt is enlarged, by the ſinking of the diaphragm, and the erection of the ribs, through the force of the muſcles placed between them.

In

In the latter, it is contracted; the diaphragm riſing and the ribs falling again. Whenever the cavity of the breaſt is enlarged, the air by its weight naturally preſſes into it, and mixing with the blood in the veſicles of the lungs, makes it more fluid, globular and fit for motion. Air is likewiſe abſolutely neceſſary in the body, to counteract the preſſure of the outward air.

But if the blood in the lungs of a fœtus has not the advantage of reſpiration, it receives a portion of air, tranſmitted with its mother's blood by the umbilical veſſels, to be diffuſed through the body. This is quite neceſſary, as appears hence: tie the navel ſtring very tight, and the child dies, like a man ſtrangled.

One uſe of reſpiration is, to puſh the blood from the right to the left ventricle of the heart: hence it is, that perſons ſtrangled, ſo ſuddenly die, becauſe with reſpiration, the circulation of the blood ceaſes. And this is the true cauſe of the diaſtole of the heart: the weight of the incumbent atmoſphere, being the true antagoniſt to all the muſcles that ſerve both for inſpiration and the contraction of the heart. As in the elevation of the ribs, a paſſage is opened for the blood into the lungs, ſo in the depreſſion thereof, by the ſubſiding of the lungs and compreſſion of the blood-veſſels thereby, the blood is driven through the pulmonary vein, into the left ventricle of the heart. And this, together with the general compreſſion of the body, by the weight of the atmoſphere, is that power which cauſes the blood to mount in the veins, when the force, impreſt on it by the heart, is nearly ſpent, and which forces the heart itſelf from its natural ſtate of contraction, to that of dilatation.

When in an ordinary expiration, the preſſure on the larynx is two ounces, the preſſure on the whole internal ſubſtance of the lungs, is 14412 pounds. So vaſt is the extent of the ſurface of the veſicles, on which it was neceſſary the blood ſhould be ſpread in the fineſt capillary veſſels, that each globule of blood might, as it were, immediately receive the whole force of the air, and thereby be broken into ſmaller parts, fit for ſecretion and circulation.

And

And hence we ſee the reaſon for the ſtructure of the lungs. For ſince all the blood is to paſs through them, in order to receive the effect of the air, and that this could not be done, unleſs it were diffuſed in very ſmall veſſels: it was neceſſary the ſurface on which they were to be ſpread, ſhould be proportioned to their number. And this is admirably well provided for, by the fabric of the lungs.

If the diameter of the trachea at the time of every expiration were the ſame in all, and the weight of the air always equal, the preſſure on the lungs would be always the ſame. But as the difference between its leaſt and greateſt gravity, is no leſs than a tenth part of the whole, that preſſure is likewiſe greater by a tenth part at ſome times than it is at others.

This is a difference which the aſthmatic muſt ſenſibly feel; eſpecially as they breathe thicker, that is, every expiration is performed in leſs time. In truth, theſe feel a difference in the air, upon the greateſt riſe and fall of the barometer, equal to above one third of its preſſure in ordinary breathing.

The alternate dilatation and contraction of the thorax are ſo neceſſary to animal life, that there is no animal without this, or ſomething analogous to it. Fiſhes and inſects have no dilatable thorax. But fiſhes have gills, which receive and expel the water alternately, whereby the blood-veſſels ſuffer the ſame alterations of dimenſions as thoſe in our lungs do. And inſects have air-veſſels diſtributed through the whole trunk of their bodies. By theſe they communicate with the external air through ſeveral vent-holes, to which are faſtened ſo many wind-pipes, which ſend branches to all parts, and ſeem to accompany the blood-veſſels all over the body, as they do in our lungs only. And hereby in every inſpiration the whole body is dilated, and in every expiration compreſſed.

But may it not be doubted, whether the primary end of reſpiration be not to ſupply the whole animal machine with the ethereal fire, a particle of which is connected with every particle of air? Is not this detached from it by the action of the lungs, and thence communicated to every part of the body? And is not

this

this the true vital flame, the original ſource of life and motion?

4. Chylification is preceded by digeſtion, which is much illuſtrated by Mr. Papin's digeſter. This is a veſſel wherein meat is put, with juſt as much water as will fill it. Then the lid is ſcrewed on ſo cloſe, as to admit of no external air. The meat herein is by the flame of a ſmall lamp, in ſix or eight minutes brought to a perfect pulp. In a few minutes more the hardeſt bones are reduced to a jelly. No air entering, the ſuccuſſions cauſed by the air, encloſed in the fleſh, reſolve the whole into one homogeneous body. It is juſt ſo in digeſtion. In proportion to its heat, the ſtomach does the very ſame thing as the digeſter.

Add to this, that the muſcular coat of the ſtomach continually contracting, and preſſing its contents by its periſtaltic motion, occaſions a more intimate mixture, and works the more fluid parts, through the pylorus into the duodenum. Along the ſides of this and the other ſmall inteſtines the lacteals are planted: into the minute orifices thereof, the chyle or finer part of the maſs is received. The lacteal veins of the firſt kind diſcharge themſelves into the glands of the baſis of the meſentery. The chyle is afterwards received by the lacteals of the ſecond kind, and conveyed into glands between the two tendons of the diaphragm. And hence it is carried to the heart, where it mixes with the blood.

5. By the perpetual motion of the fluids (eſpecially in the minute veſſels) as well as the conſtant action of the muſcles, ſmall particles are continually worn off, from the ſolids of the body. The fluids likewiſe are continually diminiſhing. And hence every animal body, by the very condition of its frame, is liable to deſtruction. To prevent this, a reſtitution muſt be made to the juices and ſolids of the body, equal and ſimilar to what is loſt. And this we call nutrition.

It ſeems to be performed thus. The blood forcibly thrown by the heart into the arteries, endeavours to go out every way through the pores. But theſe are uſually too ſmall to give its particles a free paſſage.

They can only paſs where any of the pores are open. Here one will naturally follow another in a line, and conſtitute a fibre or part of a fibre. When as much is thus added to one end of the fibre, as is waſted at the other, the body is nouriſhed: when more is added than is waſted, we are ſaid to grow.

We ſee then how abſolutely neceſſary food is, to repair the conſtant decay of the body: ſo that few men or women can live without it, above five or ſix days. And yet the abſtaining from it, for a ſeaſon, has its uſe. Indeed great is the efficacy of abſtinence, both in prolonging life beyond its uſual period, and in the cure of many ſtubborn diſorders.

Lewis Cornaro, a nobleman of Venice, after all other means had failed, ſo that his life was deſpaired of at forty, recovered and lived to near a hundred, by mere dint of abſtinence.

It is ſurpriſing to obſerve, to what an age thoſe ancient chriſtians lived, who retired from the fury of perſecution, into the deſerts of Arabia and Egypt. They drank only water, and took no other food than 12 ounces of bread in 24 hours. On this St. Anthony lived 105 years, Epiphanius 115, Simon Stylites 112, and Romuald 120.

Among animals we ſee ſurpriſing inſtances of long abſtinence. Several ſpecies paſs four, five, or ſix months every year without eating or drinking. So tortoiſes and dormice regularly retire at the ſeaſon to their reſpective cells. Some kinds get into ruins, or the hollows of rocks; others, into clefts of trees. Some ſleep in holes under the earth: others bury themſelves under water.

The ſerpent-kind bear abſtinence to a miracle. Rattleſnakes will ſubſiſt many months without food. Dr. Shaw ſaw two Egyptian ſerpents, which had been kept in a bottle five years, (on a ſmall quantity of ſand wherein they coiled themſelves up) without any ſort of food. Yet when he ſaw them they had juſt caſt their ſkins, and were as lively as if juſt taken.

There have been inſtances even of men paſſing ſeveral months, with ſcarce any ſuſtenance. So Samuel Chilton, of Tinſbury, near Bath, in the year 1693, 1694,

1694, and 1695, ſlept ſometimes four months, and ſometimes above ſix together, with very little food: and ſix weeks without any, but a little tent conveyed with a quill through his teeth.

And ſince this, John Ferguſon, of Killmelford, in Argyleſhire, about eighteen years ago, over-heated himſelf, drank largely of cold water, and fell aſleep. He ſlept for four and twenty hours, and waked in a high fever; ever ſince his ſtomach loaths, and can retain no kind of aliment but water. A neighbouring gentleman to whom his father is tenant, locked him up for twenty days, ſupplying him daily with water, and taking care that he ſhould have no other food. But it made no difference, either in his look or ſtrength. He is now ſix and thirty years of age, of a freſh complexion, and as ſtrong as any common man.

Still more ſtrange is the caſe of Gilbert Jackſon. About fifteen years of age, in February 1716, he was ſeized with a violent fever: it returned in April, for three weeks, and again on the tenth of June: he then loſt his ſpeech, his ſtomach, and the uſe of his limbs, and could not be perſuaded either to eat or drink any thing. May the 17th, 1717, his fever left him, but ſtill he was deprived of ſpeech and of the uſe of his limbs, and took no food whatever. June 30th, he was ſeized with a fever again, and the next day recovered his ſpeech, but without eating or drinking, or the uſe of his limbs. On the 11th of October he recovered his health, with the uſe of one of his legs, but neither ate nor drank; only ſometimes waſhed his mouth with water.

On the 18th of June, 1718, the fever returned and laſted till September. He then recovered, and continued in pretty good health, and was freſh coloured, but took no kind of meat or drink. On the 9th of June, 1719, he was again ſeized with a ſevere fever. On the tenth, at night, his father prevailed on him to take a ſpoonful of milk, boiled with oatmeal. It ſtuck ſo long in his throat, that his parents feared he had been choaked; but ever ſince that time he has taken food, though ſo little, that a half-penny loaf ſerves him for eight days. All the time he faſted, he had no evacuation,

cuation, either by ſtool, or urine: and it was fourteen days after he began to eat, before he had any. He is now in pretty good health.

I ſuppoſe ſuch another inſtance as this, has ſcarce been known in the memory of man.

It is not improbable, that the air itſelf furniſhes ſome nutritive particles. It is certain, there are ſubſtances of all kinds, floating in the atmoſphere. And that an animal body may be nouriſhed hereby, is evident in the caſe of vipers. Theſe, if taken, when firſt brought forth, and kept from every thing but air, will yet grow very conſiderably in a few days.

6. As without reſpiration and nutrition we cannot live at all, ſo without ſenſe, life would be like death. In every ſenſation there is, 1. An outward object. 2. Its action in the organ of ſenſe. 3. A perception of it in the mind. The action of the object on the organ, is by means of the nerves communicated to the brain. And then, not otherwiſe, the perception follows. But how, none but he that made man can explain.

7. In ſight, the action on the organ is performed juſt in the manner of that in a camera obſcura. The rays of light reaching from the ſurface of bodies to the eye, variouſly penetrate the coats and humours of it, and paint on the bottom of the eye the images of the things which we ſee. This is communicated by the optic nerve to the brain, and then the perception, which is properly ſight, follows. But the eye has many advantages above a camera obſcura: not only as it can be moved various ways, by the help of its muſcles; but alſo as the pupil, by the help of the iris, is inſtantly either dilated or conſtringed, according to the degree of light. The eye likewiſe accommodates itſelf to the various diſtances of the objects, the bottom of the eye approaching to or receding from the cryſtalline humour, as the object is nearer or farther off.

8. Sound is a tremulous motion of the air, produced by the ſtroke or colliſion of bodies. Hearing

is

is performed in the following manner. The undulating air enters the outward cavity of the ear, and then ſtrikes upon the drum: from which the motion is communicated to the little bones within, and the air contained in the inner cavity. This by means of the nerve conveys it to the brain, and then follows the perception which we term hearing.

9. The fine effluvia which ſpread every way from odorous bodies, aſcending with the air into the noſtrils, variouſly twitch the filaments of the olfactory nerves, according to the variety of their natures. When this motion is by thoſe nerves communicated to the brain, the perception follows which is called ſmelling.

10. It was obſerved before, that the ſurface of the tongue is filled with ſmall papillæ, which are no other than fine ramifications of the guſtatory nerve. Theſe are variouſly moved, by the particles of meat and drink. And this motion being by that nerve tranſmitted to the brain, that perception ariſes which we ſtile taſting.

11. The organ of feeling is the ſkin in general, with which innumerable nervous papillæ are interwoven, which being moved by the ſlighteſt touch of other bodies, convey that motion to the brain. But theſe papillæ abound in all the extremities, particularly the palms of the hand, and the tips of the fingers. And hence it is, that the ſenſe of feeling is far more exquiſite in thoſe, than in other parts.

12. Nearly allied to the ſenſes are the natural appetites, particularly hunger and thirſt. The uſual way of accounting for them is this. When the food, now reduced to a pulp, is expreſt out of the ſtomach, it is of courſe contracted by its muſcular coat. This cauſes the inner coat to lie in folds; which by means of the periſtaltic motion, rubbing lightly on each other, occaſion the uneaſy ſenſation which we term hunger. This is felt firſt in the upper orifice which is firſt evacuated. But as by degrees the reſt of the contents are expelled,

expelled, this rubbing of the membranes on each other ſpreads over the whole ſtomach, and renders our hunger more urgent.

This uneaſy ſenſation is increaſed by the acidity, which the blood in the arteries of the ſtomach contracts through long abſtinence, its ſoft balſamic parts having been all drawn off. Likewiſe its velocity is conſiderably augmented, when we have not eaten for ſome time.

Hence it is, that hunger, if it continue long, will occaſion a violent fever: that young perſons, and thoſe who labour hard, or are of a bilious conſtitution, are ſooneſt hungry: whereas thoſe whoſe humours are thick and viſcid, are not ſo ſoon incommoded therewith.

13. Hot vapours aſcending from the ſtomach, and drying the throat and mouth, are ſuppoſed to be the occaſion of that uneaſy ſenſation, which we term thirſt.

I ſay, are ſuppoſed. For I apprehend nothing can be known with any certainty upon the head. In like manner it is ſuppoſed, that we are then awake, when the nerves are braced, and filled with animal ſpirits; and that when they are unbraced and empty, we ſleep. But who can give any ſatisfactory account of ſleep? Some aſcribe it to the ſtoppage of the nerves: ſome to the quieſcency, and others to a deficiency of the animal ſpirits. The truth is, we are ignorant of the whole affair; and no more underſtand ſleep than we do death.

But this we know, that during ſleep ſeveral functions are ſuſpended, the organs of ſenſe are at reſt, the muſcles are quieſcent, ſo that hardly any ſpirits flow through them. The fibres of the nerves are little changed, and an equilibrium obtains throughout. There is no difference of preſſure on the veſſels, nor of velocity in the humours, which circulate equally through all the canals. Mean time, all diſturbing cauſes being at reſt, the waſted humours are reſtored, and the particles ſupplied, which were worn off the ſolids.

We

We may obſerve farther, that when the head is hot, and the feet cold, we cannot ſleep; that perſpiration is twice as great while we ſleep as while we are awake; that too much ſleep makes the ſenſes dull, the memory weak, and the whole body liſtleſs; that ſleep will for a conſiderable time ſupply the place of meat and drink: that a fœtus ſleeps always; children much; youths more than adults, and they than old men.

To ſpeak a little more particularly. While we are awake there is a continual motion of the voluntary muſcles, of the parts ſubſervient to ſenſe, and to the affections, all which ſtimulate the nerves, blood-veſſels and heart. Thus the finer parts of the blood are continually waſted, whence wearineſs enſues: and if the vigilance be continued, a feveriſh heat and ſenſible loſs of ſtrength.

As the night advances, a weight falls on the large muſcles and their tendons; and the mind becomes heavy. The powers that hold the body erect, begin to ſhrink from their office, the eye-lids cloſe, the head nods, and we take leſs notice of outward objects, till at length all the thoughts are in confuſion, and a ſort of delirium enſues, from whence there is a tranſition to ſleep, not known to us. This is haſtened by darkneſs, compoſure of mind, and abſence of irritation from all parts of the body.

Again, whatever weakens the natural powers, inclines to and increaſes ſleep: ſuch as loſs of blood, cooling medicines, yea the cold of the external air. Add to theſe, whatever calls off the quantity of blood flowing to the heart, as warm bathing of the feet, a plentiful ingeſtion of food into the ſtomach: likewiſe whatever leſſens the motions of the ſpirits, whether in the brain, or ſtomach, heart, or arteries.—On the contrary, ſome hot medicines induce ſleep, by cauſing a greater afflux of blood to the brain. The ſame effect have ſome fevers; as alſo fatneſs, and whatever elſe retards the venal blood. In all theſe caſes, the blood collected in the head compreſſes the brain, ſo as to leſſen the courſe of the ſpirits into the nerves.

Sleepineſs is likewiſe produced by any compreſſion of the brain, whether from extravaſated blood, a de-

preſſed

preſſed part of ſome bones, or a collection of ſerous water within the ventricles.

Sleep therefore ſometimes riſes from a defect of the ſpirits: always from a collapſing of the nervous fibres, through which the ſpirits paſs from their fountain to all parts of the body.

It is hindered by intenſe thought, pain of body, and ſtrong emotions of mind: all which urge the ſpirits on, and prevent the nervous fibres from collapſing.

In ſleep, the heart is gradually reſtored from its quick and almoſt feveriſh pulſation, to its ſlow and calm motion: the breathing is ſlower and ſmaller, the motion of the ſtomach and inteſtines, the digeſtion of the aliments and the progreſſion of the fæces are diminiſhed. At the ſame time the thinner juices move more ſlowly, while the more groſs are called together, the fat is accumulated in its cells, and the nutritive particles adhere more plentifully to the inner ſurfaces of the ſmall veſſels, and the ſides of the fibres. Thus while the ſpirits are ſecreted with a leſs conſumption, they are by degrees accumulated in the brain, ſo as to diſtend and fill the collapſed nerves. And then we awake out of ſleep.

Let us conſider in another view theſe remarkable incidents of our frame, ſleep and dreams: ſo remarkable, that they are a kind of experimental myſtery, a ſtanding miracle. Behold the moſt vigorous conſtitution, when reſigned to the ſlumbers of the night. Its activity is oppreſſed with indolence; its ſtrength ſuffers a temporary annihilation. The nerves are like a bow unſtrung, the whole animal like a motionleſs log. Behold a perſon of the moſt delicate ſenſations and amiable diſpoſitions. His eyes, if wide open, diſcern no light, diſtinguiſh no objects. His ears, with the organs unimpaired, perceive not the ſounds that are round about them. The exquiſitely fine ſenſe of feeling is overwhelmed with an utter ſtupefaction. Where are his ſocial affections? He knows not the father that begat him, the friend that is as his own ſoul. Behold the moſt ingenious ſcholar, whoſe judgment traces the moſt intricate ſciences, whoſe taſte reliſhes all the beauties of compoſition. The thinking faculties are unhinged, and inſtead of cloſe-connected reaſonings, there

is

is nothing but a disjointed huddle of absurd ideas. Instead of well-digested principles, nothing but a disorderly jumble of crude conceptions.

Yet no sooner does he awake, than he is possest of all his former endowments. His sinews are braced and fit for action, his senses alert and keen. The frozen affections melt with tenderness: the romantic visionary is again the master of reason. And (what is beyond measure surprising) the intoxicated mind does not work itself sober by slow degrees; but in the twinkling of an eye, is possest of all its faculties! Why does not the numbness, which seized the animal powers, chain the limbs perpetually? Why does not the stupor, that deadens all the senses, hold fast its possession? When the thoughts are once disadjusted, why are they not always in confusion? How is it, that they are rallied in a moment, and reduced from the wildest irregularity, to the most orderly array? From an inactivity resembling death, and from extravagancies little differing from madness, how suddenly is the body restored to vigour and agility? How instantaneously is the mind re-established in sedateness and harmony! Surely "this is the Lord's doing, and it is marvellous in our eyes!"

14. That all motion is performed by means of the muscles, all men are now agreed. And it is supposed that the motions of the muscles proceed from the influx of the animal spirits; which, entering them by means of the nerves, swell and shorten the belly of the muscle, and thereby draw the extremities together, and move the parts connected therewith. But all this likewise is mere conjecture. God only knows his own work.

15. That some motions are voluntary, and some are not, is another amazing proof of the Creator's wisdom. Those which are absolutely necessary for the conservation of the machine, as the beating of the pulse, and the circulation of the blood, go on by a kind of mechanic law, which no way depends upon our will: while a thousand other motions begin and end, by a single act of our will, when we please. But

how

how this bodily motion is connected with that act of our mind, who is able to explain?

16. There is a manifeſt congruity between the ſtature of man, and his age, during the time of his growth. And as five feet and a half may be thought the ordinary height of man, ſo may ſeventy years the ordinary period of his life. Yet ſome vaſtly exceed in both reſpects. And as we know Thomas Parre and Henry Jenkins completed double that uſual term of life, ſo we have no reaſon to queſtion, that ſome have doubled the common ſtature of man. Walter Parſons, King James the Firſt's porter, was full ſeven feet, ſeven inches high. Mr. Ray ſaw a man at Bruges, who was eight feet and a half; all his limbs well ſhaped, and his ſtrength proportionable. Becanus ſays, he ſaw a youth almoſt nine feet high; a man near ten, and a woman quite ten feet. Pliny mentions ſeveral men of the ſame height in his age. Yea, Thevenot tells us, that he met a Spaniſh merchant on the coaſt of Afric, who had in a coffer the ſcull and bones of an American giant, which he brought with him from that country, who was eleven feet, five inches in height, and died in the year 1559.

From theſe warrantable accounts we learn, that there have been men 11 or 12 feet high, which equals, if not exceeds, the ſtature of the talleſt giant mentioned in ſcripture. The height of Goliah was but ſix cubits and a ſpan, which is only nine feet, nine inches. Indeed the bedſtead of Og, the King of Baſan, is ſaid to have been nine cubits in length. But his bed muſt have been longer than his body: we may fairly allow nine inches above his head, and as much below his feet. And making this deduction, he was not above twelve feet high: much of the ſame ſtature with the giant, whoſe forehead bone is ſtill kept in the medicine-ſchool at Leyden.

Is this deviation from the common ſtature of man by largeneſs, more remarkable than its oppoſite? The deviation from it by littleneſs, which has been obſerved in ſome inſtances? Such was the dwarf, who lived for ſeveral years in the palace of the King of Poland. His parents were healthy, ſtrong peaſants, who affirmed,

affirmed, that at his birth he weighed ſcarce a pound and a quarter; that he was preſented on a plate to be baptized, and for a long time had a wooden ſhoe for his bed. When 18 months old, he could ſpeak ſome words; when two years old, he could walk almoſt without help. His ſhoes were then juſt an inch and a half long. When he was ſix years of age, the King of Poland gave him the name of Bebe, and kept him in his palace. His height was then fifteen inches, and he weighed thirteen pounds. He was in perfect health, his perſon was agreeable and well proportioned; but there was little appearance of underſtanding. He had no ſenſe of religion, was incapable of reaſoning, and could learn neither muſic nor dancing. Yet he was ſuſceptible of paſſions in a high degree, anger and jealouſy in particular. When 16 years old, he was 29 inches high, being ſtill healthy and well proportioned: but from that time his health declined; yet he grew four inches in the four ſucceeding years. At 21 he was ſhrunk and decrepit; and at 22 it was with difficulty he could walk a hundred ſteps. In the 23d year he fell into a kind of lethargy, and in a few days died, as it were of old age.

17. The two moſt eminent inſtances of longevity in England were Thomas Parre and Henry Jenkins. Thomas Parre was a poor countryman of Shropſhire, whence he was brought up to London, by Thomas Earl of Arundel. At the age of 120 he married a widow: at 130 he could do any huſbandry-work, even threſhing of corn, although ſoon after, his ſight began to fail; nor had he the uſe of his memory, or but in a ſmall degree for ſeveral years before he died: but he retained his hearing and apprehenſion to the laſt. He uſed to eat often, by day and by night, of milk, old cheeſe with coarſe bread, whey and ſmall beer. He died at the age of a hundred and fifty-two years and nine months. He might have lived much longer, but coming out of a clear, thin, and free air to London, and from a plain country diet, to that of a ſplendid family, where he fed high, and drank the beſt wines, the natural functions were over-charged, and death could not but ſoon enſue.

142-9
169

" Henry

" Henry Jenkins calling at my houſe, I aſked how old he was? " He pauſed and ſaid, " About 162, or 163." I aſked, what was the firſt public tranſaction he remembered? He ſaid, " The battle of Flowden-field, being then 11 or 12 years old."

For many years he was a fiſherman, and uſed to wade in the ſtreams. After he was a hundred years old, he frequently ſwam in the rivers. The latter part of his life, he was obliged to beg. He died at Ellerton-upon-Swale, in Yorkſhire, Dec. 8, 1670: having lived (ſuppoſing him to have been 12 years old, at the battle of Flowden-field, which was fought Sept. the 9th, 1513) a hundred and ſixty-nine years, that is, ſixteen longer than Thomas Parre.

CHAP. III.

Of the preternatural State of the Human Body.

1. *What the preternatural State of the Body means.*
2. *The Variety of Diſeaſes.*
3. *Reduced to three Claſſes: thoſe of the Solids.*
4. *Thoſe of the Fluids, particularly the Blood.*
5. *Thoſe of the Animal Spirits.*
6. *The remote Cauſes of Diſeaſes.*
7. *Of Fevers.*
8. *The Way to preſerve Health.*
9. *Of Life and Death.*

1. WHEN the ſtructure or diſpoſition of the parts of the body is ſo diſturbed and diſordered, that the natural operations are no longer performed, or not in the manner they ought: this is a preternatural ſtate of the body, otherwiſe termed a diſeaſe.

2. There cannot but be a great variety of diſeaſes, whether we conſider the manner, wherein that ſtructure or diſpoſition is diſturbed, that part wherein each diſeaſe has its ſeat, or the various effects and circumſtances

ſtances of them. Some diſeaſes only hurt the uſe of the parts; ſome wholly deſtroy it. Some affect this or that part; others the whole body. Some diſorder the body, ſome the mind; and others both mind and body.

3. But they are all reducible to three claſſes, thoſe of the ſolids, of the fluids, and of both. The ſolid parts may be bruiſed, wounded, ſwelled, or removed out of their natural place.

It is a wonderful proviſion which nature makes in one of the moſt dreadful calamities incident to the ſolids. When a bone is broken, let it only be replaced, and preſerved in that ſituation, and nature does the reſt, by ſupplying the divided parts with a callus.

This oozes out from the ſmall arteries and bony fibres of the divided parts, in form of a jelly, and ſoon fills up the cavities between them. It ſoon grows cartilaginous, afterwards bony, and joins the fractured parts ſo firmly, that the bone will be more eaſily broken in any other part than in that.

A callus of a different kind is formed on our hands and feet. This is compoſed of ſeveral layers of particles looſely connected. Theſe, if ſteeped in fair water eaſily ſeparate; and then are found, if viewed through a microſcope, to be all of one ſhape, reſembling that of a weaver's ſhuttle, broad in the middle and pointed at each end. Being ſteeped again, they divide into a great number of ſmaller particles, all of the ſame figure with the firſt.

The thickneſs of the ſkin in the hands of thoſe who labour hard, is wholly owing to vaſt numbers of theſe particles which combine together, but ſo looſely that they are eaſily ſeparated on moiſtening. That thick ſkin is compoſed of ſeveral layers of different thickneſs, which have been added from time to time: each of which layers is only a congeries of almoſt an infinity of theſe particles.

But people who labour ever ſo hard, will have little callus on their hands if they waſh them often. The waſhing the hands daily rubs off a great quantity of theſe ſcales. Indeed it is ſurpriſing to ſee, how large a quantity of them is daily thrown off from our hands

and

and feet, though from no other part of the body. We may learn from this the great bounty of nature, in ſo carefully ſupplying the parts deſigned for walking or labour, with an additional matter for their defence, which is not in any other part of the body.

4. The diſeaſes of the fluids lie chiefly in the blood, when it is either too thick and ſizy, whereby its motion becomes too languid and ſlow, whence ſpring the diſeaſes owing to obſtruction: or too thin. From the former cauſe ariſe leproſies, ſcirrhus's, lethargies, melancholy, hyſteric affections: and if at the ſame time it abounds in acid ſalts, the ſharp points of theſe tear the tender fibres, and occaſion the ſcurvy, king's-evil, conſumption, with a whole train of painful diſtempers.—Fevers frequently ariſe from the too great thinneſs in the blood.

The plague is not an European diſeaſe. It is properly a diſeaſe of Aſia, where it is epidemical, and is never known elſewhere, but by importation from thence. The ſmall-pox alſo is an exotic diſeaſe, and was not known in Europe, or even Aſia Minor, till a ſpice-trade was opened by the later princes of Egypt, to the remoteſt part of the Eaſt-Indies. Thence it originally came, and there it rages at this day.

5. As to the diſeaſes aſcribed to the animal ſpirits, ſome are thought to proceed from the ſuppreſſion or diminution of their motion, as apoplexies and palſies: ſome from their exceſſive or irregular motion, as madneſs, convulſions, epilepſies.

I know not whether the gentlemen of the faculty would not term the following, "a diſeaſe of the animal ſpirits." Donald Munro, at Strathbogie, in Scotland, imitates unawares all the motions of thoſe he is with. He is a little ſlender, old man, and was ſubject to this infirmity from his infancy. He is loath to have it obſerved, and therefore caſts down his eyes in the ſtreets, and turns them aſide when in company. We had made ſeveral trials before he perceived it, and afterward had much a-do to make him ſtay. He imitated not only our ſcratching our heads, but the wring-

ing

ing our hands, and every other motion. We needed not to perſuade him to be covered; for he ſtill covered or uncovered as we did: and all ſo exactly, and yet with ſuch a natural and unaffected air, that none could ſuſpect he did it deſignedly. When we held both his hands, and cauſed another to make ſuch motions, he ſtruggled to get free. But when we would have known more particularly, how he found himſelf affected, he would only give us this ſimple anſwer, That "it vexed his heart and his brain."

But to what claſs ſhall we refer the diſeaſe of Ann Jackſon? She was born at Waterford, of Engliſh parents, both ſaid to be ſound and healthy, and from three years old, had horns growing on various parts of her body. She is now thirteen or fourteen: the horns grow chiefly about the joints; they are faſtened to the ſkin like warts, and about the roots reſemble them much in ſubſtance, but toward the end are much harder. At the end of each finger and toe is one, as long as the finger or toe itſelf, riſing a little between the nail and fleſh, and bending again like a turkey's claw. On the joints of each finger and toe are ſmaller ones, which ſometimes fall off, but others come in their place. Round her knees and elbows are many; two in particular at each elbow, which twiſt like rams-horns. At each ear grows one: yet ſhe eats and drinks heartily, ſleeps ſoundly, and performs all the offices of nature, like other healthy perſons.

6. Such are the proximate cauſes of diſeaſes. As to the remote, the chief are theſe, 1. Intemperance in meat or drink, either with regard to the quantity or quality. 2. Want of exerciſe, or exceſs therein. 3. Immoderate ſleep or watching. 4. Unwholeſome air. 5. The diminution of ſome natural evacuation. 6. Irregular paſſions. All or any of theſe affect the temperature and motion of the blood and ſpirits.

7. But it can ſcarce be conceived, after all that has been ſaid and wrote, on almoſt every ſubject, how very little is known to this day, concerning the cauſes of diſeaſes. In moſt caſes the moſt ſkilful phyſicians acknowledge

knowledge they have nothing but conjectures to offer. We may give a ſpecimen with regard to fevers, the moſt common of all diſtempers. Theſe are of various kinds: at preſent we will ſpeak of intermitting fevers only. Moſt of theſe agree in the following ſymptoms. During the approach of the fit, cold and ſhivering ſeize the body, with a ſmall and ſlow pulſe. Heat ſucceeds, with a quick, ſtrong, hard pulſe, followed by ſweat and a ſofter pulſe. Theſe fits return at ſtated times.

It is ſuppoſed, that theſe changes in the blood ariſe from ſome foreign matter mixt with it, which it cannot readily aſſimilate, and which therefore muſt in ſome meaſure hinder its motion: perhaps becauſe the particles of it are too large, too long, or branching out. When the circulation is hindered or retarded, chilneſs naturally follows. And if theſe particles ſticking in the finer paſſages are preſt on by the affluent blood, this will occaſion both a ſhock and tremor of the muſcles, and make the pulſe more weak and ſlow. But when they are at length broken and comminuted by the continued afflux of the blood, it will flow more violently, and of courſe occaſion heat, which driving the blood to the ſurface of the body, many of its thinner particles will burſt through the pores, in the form of ſweat. As to the fevers returning at ſtated times, it is ſuppoſed, the peccant matter is generated from time to time, and mingled with the blood afreſh; whence the ſame ſymptoms of courſe return, and that with more or leſs violence, as more or leſs of that matter is generated. And as this is done more ſwiftly or ſlowly, the fever returns in one, two, or three days. But all this is mere conjecture. It may be ſo; and it may not. So that though we may gueſs much, we know nothing about it.

8. It is ſufficient for us to know, how we may avoid diſeaſes, whether we can account for them, or not. To this end, we ſhould avoid whatever in meat, drink, motion or reſt, is likely to produce any conſiderable change in the blood. The body likewiſe ſhould be as far as poſſible accuſtomed to bear ſome change of food, air, and other externals, that if we ſhould at any time be

be conſtrained to make ſuch a change, no ill conſequence may enſue. But no preciſe rule can be laid down, which will ſuit all conſtitutions. Every man muſt conſult his own reaſon and experience, and carefully follow them.

A moſt unaccountable method of removing many diſeaſes, was that of the famous Mr. Greatrix. "I give you nothing concerning him, ſays Mr. Boyle, but from eye-witneſſes. My own brother, ſome time ſince was ſeized with a violent pain in his head and back. Mr. Greatrix coming by accident to our houſe, gave preſent eaſe to his head by ſtroking it. He then ſtroked his back: the pain immediately fled to his right thigh. He purſued it with his hand to the knee, ankle, foot, toe, then he ſtroked this, and it was gone.

My uncle's daughter was ſeized with a pain in her knees, which occaſioned a white ſwelling. She tried many remedies without effect, for ſix or ſeven years. Mr. Greatrix then coming to Dublin, my aunt brought her to him. He ſtroked her knees, and the pain fled downward from his hands, till he drove it out of her toes. And in a little time the white ſwelling went away.

I had an acquaintance, who after a fever was very deaf, and had a violent pain in her ears. Mr. Greatrix put ſome ſpittle into her ears and rubbed them, which cured both the pain and deafneſs.

Another told me, that when a child, ſhe was extremely troubled with the king's-evil. She tried many remedies in vain: but Mr. Greatrix ſtroked and perfectly cured her. A ſmith near us had two daughters troubled with the ſame diſtemper. One of theſe had a running ſore in the thigh, the other in the arm: he cured them both. He cured all kinds of hyſteric fits. He likewiſe cured the falling ſickneſs, and without any relapſe, provided he could ſee the patient in three or four fits."

9. As long as the ſoul and body are united, a man is ſaid to be alive. But it is extremely difficult to determine the preciſe time at which life ceaſes, or what

that is, which is abſolutely neceſſary to the continuance of it. Is reſpiration? But when this is entirely ceaſed, as is the caſe in a perſon ſtrangled, blow ſtrongly into the lungs, and they play again; which ſhews he was not dead before.—Is the beating of the heart? But when this alſo is ceaſed, in the forementioned caſe, take the ſame method, and when the lungs begin to play, the heart begins to beat anew.—Is the circulation of the blood? But perſons drowned, who have been ſo long under water, as to have no pulſe remaining in any artery, and conſequently no circulation, have recovered by the uſe of proper means, and lived many years after.—Is the fluidity of the blood? Nay, but it is a common thing in Sweden, to recover to life one who has been twenty-four hours under water; and who not only has no pulſe, but is as ſtiff all over, as any dead corpſe can be. What then is death? Undoubtedly it is the ſeparation of the ſoul and body. But there are many caſes wherein none but God can tell the moment wherein they ſeparate.

Many who ſeem to be dead, may be recovered.—— A perſon ſuffocated by the ſteam of coals, ſet on fire in the pit, fell down as dead. He lay between half an hour and three quarters, and was then drawn up, his eyes ſtaring, his mouth gaping, his ſkin cold: not the leaſt breathing being perceivable, nor the leaſt pulſe either in his heart or arteries.

A ſurgeon applied his mouth to that of the patient, and by blowing ſtrongly, holding the noſtrils at the ſame time, raiſed the cheſt by his breath. Immediately he felt ſix or ſeven quick beats of the heart: the lungs began to play, and ſoon after the pulſe was felt in the arteries. He then opened a vein, which at firſt bled drop by drop, but in a while bled freely. Mean time he cauſed him to be pulled and rubbed. In an hour he began to come to himſelf; in four hours walked home, and in four days returned to his work.

Wherever the ſolids are whole, and their tone unimpaired, where the juices are not corrupted, where there is the leaſt remains of animal heat, it would be wrong not to try this experiment. This takes in a few diſeaſes,

eaſes, and many accidents. Among the firſt are many that cauſe ſudden deaths, as apoplexies and fits of various kinds. In many of theſe it might be of uſe to apply this method: and in various caſualties, ſuch as ſuffocations from the damps of mines and coal-pits, the condenſed air of long-unopened wells, the noxious vapours of fermenting liquors received from a narrow vent, the ſteam of burning charcoal, arſenical effluvia, or thoſe of ſulphureous mineral acids.—And perhaps thoſe who ſeem to be ſtruck dead by lightning, or any violent agitation of the paſſions, as joy, fear, anger, ſurpriſe, might frequently be recovered by this ſimple proceſs.

The animal machine is like a clock: the wheels whereof may be in ever ſo good order, the mechaniſm complete in every part, and wound up to the full pitch; yet without ſome impulſe communicated to the pendulum, the whole continues motionleſs.

Thus in theſe accidents, the ſolids are whole and elaſtic, and the juices no otherwiſe vitiated, than by a ſhort ſtagnation, from the quieſcence of that moving ſomething, which enables matter in animated bodies, to overcome the reſiſtance of the medium it acts in. Inflating the lungs, and thus communicating motion to the heart, like giving the firſt vibration to a pendulum, enables this ſomething to reſume the government of the fabric, and actuate its organs afreſh.——It has been ſuggeſted, That "a pair of bellows might be applied, better than a man's mouth." But, 1. Bellows may not be at hand: 2. The lungs of one man may ſafely bear as great a force, as the lungs of another can exert, which by the bellows cannot always be determined: 3. The warmth and moiſture of the breath may likewiſe be of uſe.

But what is properly a natural death? From the very birth, every veſſel in the human body grows ſtiffer and ſtiffer by the adheſion of more and more earthy particles to its inner ſurface. Not only ſolid food ſupplies it with theſe, but every fluid that circulates through it. Hereby more and more of the ſmall veſſels are ſo filled

up, as to be no longer pervious. In proportion, the coats of the larger veſſels grow harder, and their cavities narrower. Hence the dryneſs and ſtiffneſs of all the parts, which are obſervable in old age. By this means, more and more of the veſſels are deſtroyed, the finer fluids ſecerned in leſs quantity, the concoctions weakened, and the reparation of the decayed and injured parts prevented. So that only the coarſer juices continue to run ſlowly through the larger veſſels. Soon theſe alſo not only become narrow, but ſtiff, bony, and unelaſtic, till even the great artery having loſt its ſpring, can propel the blood no longer. And then follows death by old age, which is a purely natural death. But this is a very rare caſe: it is ſeldom life is ſo long protracted, the lamp of life being eaſily blown out, when it burns with ſo feeble a flame. So that the age of man ſeldom exceeds threeſcore years and ten before duſt returns to duſt.

The term of life can be prolonged but a very little time, by any art we can uſe. A few only have lived beyond the ordinary duration of human exiſtence; ſuch as Parre, and Jenkins: yet theſe men uſed no particular arts to prolong life; on the contrary, they were peaſants, accuſtomed to the greateſt fatigues, and who had no ſettled rules. Indeed, if we conſider that the European, the Negro, the Chineſe, and the American, the civilized man, and the ſavage, the rich and the poor, the inhabitant of the city, and of the country, though all ſo different in other reſpects, are yet entirely ſimilar in the period allotted them for living; if we conſider that neither the difference of race, of climate, of nouriſhment, of convenience, or of ſoil, makes any difference in the term of life; if we conſider that thoſe men, who live upon raw fleſh, or dried fiſhes, upon ſage or rice, upon caſſava, or upon roots, nevertheleſs live as long as thoſe who are fed upon bread and meat; we ſhall readily acknowledge, that the duration of life depends neither upon habit, cuſtoms, nor the quantity of food, and that nothing can change the laws of that mechaniſm, which regulates the number of our years.

If

If there be any difference in the different period of man's exiſtence, it ought principally to be aſcribed to the quality of the air. It has been obſerved, that in elevated ſituations there have been found more old people than in thoſe that were low. The mountains of Scotland, Wales, Auvergne, and Switzerland, have furniſhed more inſtances of extreme old age, than the plains of Holland, Flanders, Germany, or Poland. But, in general, the duration of life is nearly the ſame in moſt countries. Man, if not cut off by accidental diſeaſes, is generally found to live ninety or a hundred years. Our anceſtors did not live beyond that date; and, ſince the time of David, this term has had but little alteration.

If we be aſked how, in the beginning, men lived ſo much longer than at preſent, and by what means their lives were extended to nine hundred and thirty, or even nine hundred and ſixty years, it may be anſwered, that the productions of the earth, upon which they fed, might be of a different nature at that time, from what they are at preſent. But perhaps it is better to ſay, that the term was abridged by divine command, in order to keep the earth from being over-ſtocked with human inhabitants; ſince, if every perſon were now to live and generate for nine hundred years, mankind would be increaſed to ſuch a degree, that there would be no room for ſubſiſtence: ſo that the plan of providence would be altered; which is ſeen not to produce life, without providing a proper ſupply!

But to whatever extent life may be prolonged, or howſoever ſome may have delayed the effects of age, death is the certain goal to which all are haſtening. All the cauſes of decay, which have been mentioned, contribute to bring on this dreadful diſſolution. However, nature approaches to this awful period, by ſlow and imperceptible degrees, life is conſuming day after day, and ſome one of our faculties, or vital principles, is every hour dying before the reſt; ſo that death is only the laſt ſhade in the picture: and it is probable, that man ſuffers a greater change in going from youth to age, than from age into the grave. When we firſt begin to live, our lives may ſcarcely be ſaid to be our own; as the child grows, life increaſes in the ſame pro-

portion,

portion, and is at its height in the prime of manhood. But as ſoon as the body begins to decreaſe, life decreaſes alſo; for, as the human frame diminiſhes, and its juices circulate in ſmaller quantity, life diminiſhes and circulates with leſs vigour; ſo that as we begin to live by degrees, we begin to die in the ſame manner.

Why then ſhould we fear death, if our lives have been ſuch as not to make eternity dreadful? Why ſhould we fear that moment which is prepared by a thouſand other moments of the ſame kind, the firſt pangs of ſickneſs being probably greater than the laſt ſtruggles of departure. Death, in moſt perſons, is as calmly endured, as the diſorder that brings it on. If we inquire from thoſe, whoſe buſineſs it is to attend the ſick, and the dying, we ſhall find, that, except in a very few acute caſes, where the patient dies in agonies, the greateſt number die quietly, and ſeemingly without pain. And even the agonies of the former rather terrify the ſpectators, than torment the patient; for how many have we ſeen, who have been accidentally relieved from this extremity, and yet had no memory of what they then endured? In fact, they had ceaſed to live, during that time when they ceaſed to have ſenſation; and their pains were only thoſe of which they had an idea.

The greateſt number of mankind die, therefore, without ſenſation: and of thoſe few that ſtill preſerve their faculties to the laſt moment, there is ſcarce one that does not alſo preſerve the hopes of ſtill out-living his diſorder. Nature, for the happineſs of man, has rendered this ſentiment ſtronger than his reaſon. A perſon dying of an incurable diſorder, which he muſt know to be ſo, by frequent examples of his caſe; which he perceives to be ſo, by the inquietude of all around him; by the tears of his friends, and the departure, or the face of the phyſician, is, nevertheleſs, ſtill in hopes of getting over it. His intereſt is ſo great, that he only attends to his own repreſentations; the judgment of others is conſidered as a haſty concluſion; and while death every moment makes new inroads upon his conſtitution, and deſtroys life in ſome part, hope ſtill ſeems to eſcape the univerſal ruin, and is the laſt that ſubmits to the blow.

Death,

Death, therefore, is not the terrible thing which we ſuppoſe it to be. It is a ſpectre which frights us at a diſtance, but which diſappears when we come to approach it more cloſely. Our ideas of its terrors are conceived in prejudice, and dreſſed up by fancy; we regard it not only as the greateſt misfortune, but alſo an evil accompanied with the moſt excruciating tortures: we have even increaſed our apprehenſions, by reaſoning on the extent of our ſufferings. It muſt be dreadful, ſay ſome, ſince it is ſufficient to ſeparate the ſoul from the body; it muſt be long, ſince our ſufferings are proportioned to the ſucceſſion of our ideas; and theſe being painful, muſt ſucceed each other with extreme rapidity. In this manner falſe philoſophy labours to augment the miſeries of our nature, and to aggravate that period, which nature has kindly covered with inſenſibility. Neither the mind, nor the body, can ſuffer theſe calamities; the mind is, at that time, moſtly without ideas, and the body too much enfeebled, to be capable of perceiving its pain. A very acute pain produces either death, or fainting, which is a ſtate ſimilar to death: the body can ſuffer but to a certain degree; if the torture becomes exceſſive, it deſtroys itſelf; and the mind ceaſes to perceive, when the body can no longer endure.

In this manner, exceſſive pain admits of no reflection; and wherever there are any ſigns of it, we may be ſure, that the ſufferings of the patient are no greater than what we ourſelves may have remembered to endure.

But, in the article of death, we have many inſtances in which the dying perſon has ſhewn, that every reflection that pre-ſuppoſes an abſence of great pain, and, conſequently, that pang which ends life, cannot even be ſo great as thoſe which have preceded. Thus, when Charles XII. was ſhot at the ſiege of Frederickſhall, he was ſeen to clap his hand on the hilt of his ſword; and although the blow was great enough to terminate one of the boldeſt and braveſt lives in the world, yet it was not painful enough to deſtroy reflection. He perceived himſelf attacked, he reflected that he ought to defend himſelf, and his body obeyed the impulſe of his mind, even in the laſt extremity. Thus it is the

prejudice

prejudice of perſons in health, and not the body in pain, that makes us ſuffer from the approach of death: we have, all our lives, contracted a habit of making out exceſſive pleaſures and pains; and nothing but repeated experience ſhews us, how ſeldom the one can be ſuffered, or the other enjoyed to the utmoſt.

If there be any thing neceſſary to confirm what we have ſaid, concerning the gradual ceſſation of life, or the inſenſible approaches of our end, nothing can more effectually prove it, than the uncertainty of the ſigns of death. If we conſult what Winſlow or Bruhier have ſaid upon this ſubject, we ſhall be convinced, that between life and death, the ſhade is ſo very undiſtinguiſhable, that even all the powers of art can ſcarcely determine where the one ends, and the other begins. The colour of the viſage, the warmth of the body, the ſuppleneſs of the joints, are but uncertain ſigns of life, ſtill ſubſiſting; while, on the contrary, the paleneſs of the complexion, the coldneſs of the body, the ſtiffneſs of the extremities, the ceſſation of all motion, and the total inſenſibility of the parts, are but uncertain marks of death begun. In the ſame manner alſo, with regard to the pulſe, and the breathing: theſe motions are often ſo kept under, that it is impoſſible to perceive them. By approaching a looking-glaſs to the mouth of the perſon ſuppoſed to be dead, people often expect to find whether he breathes or not. But this is a very uncertain experiment. The glaſs is frequently ſullied by the vapour of the dead man's body; and often the perſon is ſtill alive, although the glaſs is no way tarniſhed. In the ſame manner, neither burning, nor ſcarifying, neither noiſes in the ears, nor pungent ſpirits applied to the noſtrils, give certain ſigns of the diſcontinuance of life; and there are many inſtances of perſons who have endured them all, and afterwards recovered, without any external aſſiſtance, to the aſtoniſhment of the ſpectators. How careful, therefore, ſhould we be, before we commit thoſe who are deareſt to us to the grave, to be well aſſured of their departure. Experience, juſtice, humanity, all perſuade us not to haſten the funerals of our friends, but to keep their bodies unburied, until we have certain ſigns of their real deceaſe.

Indeed,

Indeed, ſoon after the creation, when the earth was to be peopled by one man and one woman, the wiſe providence of God, prolonged the life of man to above 900 years. After the flood, when there were three men to people the earth, their age was cut ſhorter. And none of theſe patriarchs, except Shem, attained to five hundred years. In the next century, none reached 240. In the third, none but Terah lived 200: men being then ſo increaſed, that they built cities, and divided into different nations. As their number increaſed, the length of their lives diminiſhed, till about the time of Moſes it was reduced to 70 or 80 years, where it ſtands at this day. This is a good medium, ſo that the earth is neither over-ſtocked, nor kept too thin of inhabitants. If men were now to live to Methuſelah's age, of 969 years, or only to Abraham's of 175, the earth would be over-peopled. If on the contrary, the age of man was limited (like that of divers other animals) to 10, 20, or 30 years, it would not be peopled enough. But at the preſent rate, the balance is nearly even, and life and death keep on an equal pace.

This is highly remarkable, that wherever any account has been taken, there is a certain rate and proportion in the propagation of mankind. Such a number marry, and ſo many are born, in proportion to the number of perſons in every town or nation. And as to births, two things are very obſervable.—One is, the proportion of males and females; fourteen males to thirteen females, which is exactly agreeable to all the bills of mortality. And this ſurpluſage of males allows one man to one woman, notwithſtanding the caſualties to which men are expoſed above women. The other is, that a few more are born, than appear to die in any place. This is an admirable proviſion for extraordinary emergencies, to ſupply unhealthy places, to make up the ravages of epidemic diſtempers, and the depredations of war; and to afford a ſufficient number for colonies, in the yet unpeopled parts of the earth. On the other hand, thoſe extraordinary expenſes, are not only a juſt puniſhment of ſin, but alſo a wiſe means, to keep the balance of mankind even. So one would be ready to conclude, by conſidering the Aſiatic, and other more fertile countries, where pro-

digious multitudes are ſwept away by wars and plagues; and ſtill they remain full of people.

As to the length of life, it has been an ancient opinion, that men lived longer in cold countries than in hot. But the reverſe is true. The inhabitants of the Caribbee Iſlands, uſually live a hundred and fifty years. In the Molucca Iſlands, the ordinary life of the natives is a hundred and thirty years. In Sumatra, Java, and the neighbouring iſlands, the life of the inhabitants commonly extends to a hundred and forty years: in the realm of Caſſuby to 150. The Braſilians, frequently live to 160 years, and many, in Florida and Jucatan, ſtill longer.

Nor is this at all improbable. For there being no ſuch inequality of weather in thoſe climates as in ours, the body is not ſhocked by ſudden changes, but kept in a more equal temper. And ſickly perſons with us, when fixt to their beds, and kept in an equal degree of heat, are often found to hold out many years, who would otherwiſe ſcarce have ſurvived one.

Before concluding this head, we may obſerve one more eminent inſtance of the divine wiſdom, in the great variety throughout the world of men's faces, voices, and hand-writing. Had men's faces been caſt in the ſame mould, their organs of ſpeech given the ſame ſound; and had the ſame ſtructure of muſcles and nerves, given the hand the ſame direction in writing: what confuſion, what numberleſs inconveniencies muſt we have been expoſed to? No ſecurity could have been to our perſons, no certainty of our poſſeſſions. Our courts of juſtice abundantly teſtify the effects of miſtaking men's faces or hand-writing. But this, the wiſe Creator has taken care to prevent from being a general caſe. A man's face diſtinguiſhes him in the light, as his voice does in the dark: and his hand-writing can ſpeak for him when abſent, and ſecure his contracts to future generations.

Laſtly, how admirably has God ſecured the execution of his original ſentence, upon every child of man, "Duſt thou art, and unto duſt ſhalt thou return?"—From the moment we live, we prepare for death, by the adheſion of duſt, mixt with all our aliments, to our native duſt; ſo that whatever we eat or drink, to

prolong life, muſt ſap the foundation of it. Thus, in ſpite of all the wiſdom of man and all the precautions which can be uſed, every morſel we take, poiſons while it feeds, and brings us nearer to the duſt from whence we came.

CHAP. IV.

Of the Soul, and of the Origin of MAN.

1. *There is ſomething in Man which perceives the various Motions of the Body.*
2. *This Perception is ſometimes continued, and recalled.*
3. *We know ſome Things in a more ſublime Manner.*
4. *There is ſomething in us which has an Appetite to ſenſible Things.*
5. *And another Appetite, which is often contrary to this.*
6. *How Philoſophers account for the Direction of our bodily Motions.*
7. *For the External Senſes.*
8. *The Imagination and Memory.*
9. *The Underſtanding, Will, and Affections.*
10. *This may be ſo, or may not.*
11. *Of the Immortality of the Soul.*
12. *Of the Union of the Soul and Body.*
13. *Reaſon cannot diſcover the Origin of Man.*
14. *The Scriptural Account of it.*
15. *Of the Production of the Soul.*
16. *Of the Generation of the Body.*

1. EVERY one finds there is ſomething in himſelf which perceives the motions raiſed in his body by outward objects. For when we ſee, hear, taſte, ſmell or feel, while the objects affect our bodily organs, we find alſo various perceptions in our mind, according to the variety of thoſe objects.

2. We obſerve likewiſe, that after the objects are removed, thoſe perceptions often continue, yea, and are variouſly mixed and compounded together, which we

term

term imagination. And a long time after, when thoſe objects are not only removed, but even ceaſe to exiſt, thoſe perceptions return into our mind. And this we call memory.

3. And as we perceive theſe outward objects, ſo we know that we do perceive them. The mind can look inward upon itſelf, and reflect upon its own perceptions. Over and above this, we ſeem to find in ourſelves, a knowledge of things abſtracted from matter. But the more we labour to penetrate into the nature of this divine principle, the more it ſeems to retire and withdraw itſelf from our moſt ſtudious reſearches.

4. In like manner we find in ourſelves various appetites for good things, and averſions to evil things: yea, the very involuntary motions of the body tend to avoid the evil and attain the good. And the things which are perceived by our ſenſes, or repreſented by our imagination, ſo neceſſarily affect us, that we can by no means hinder ourſelves from having an appetite for ſome, and an averſion to others.

5. Yet frequently a more hidden and ſublime appetite exerts itſelf in our minds: one that checks, controls, and exerciſes authority over all the reſt. For if we are convinced, that the things which are pleaſant, are nevertheleſs hurtful, the appetite for them is overruled, and we find a deſire, not to enjoy, but to avoid them.

6. In order to explain theſe things, philoſophic men ſuppoſe, that all the involuntary motions of the body, are performed in a mechanical manner, by matter ſo and ſo modified: and that ſuch effects ſpring of courſe from ſuch cauſes, according to the ſtated laws of motion.

7. As to the ſenſes, they ſuppoſe, that when the organs of ſenſe are ſtruck by any of the bodies that ſurround us, and the motion cauſed thereby continued through the nerves to the brain, the ſoul, reſiding there, is ſuitably affected: God having ſo cloſely connected

nected the ſoul and the body, that on certain motions of the body, (if conveyed to the brain by means of the nerves) certain perceptions of the mind always follow: as, on the other hand, on certain perceptions of the mind, certain bodily motions follow.

8. They ſuppoſe, if theſe motions, which are by the nerves communicated to the brain, continue there after the objects are removed, the perception of theſe is imagination: which, if it occur after it has ceaſed, is then ſtiled memory. Others ſuppoſe, that imagination reſults from the motion of the animal ſpirits, through thoſe traces which were made in the brain, while the outward objects were preſent; and memory, from the ſpirits moving through them afreſh, after ſome intermiſſion.

9. Once more. They ſuppoſe there are two faculties in the ſoul; one that is paſſive, the underſtanding, by which it perceives all the motions of the body, and knows and reflects on its own operations: the other active; the will, by which we incline to good, and are averſe to evil. The affections are only, the will exerting itſelf variouſly on various objects.

10. To ſpeak freely upon the matter. I know the body of man is contrived with ſuch exquiſite wiſdom, that he is able, by means of the organs of ſenſe, to perceive outward objects; to continue thoſe perceptions, to recal them after they are gone, and by a reflex act, to know what paſſes in his mind or body. But I know not how to account for any of theſe things.

11. That the ſoul is immaterial, is clear from hence, that it is a thinking ſubſtance. If it be ſaid, "God can endue matter with a faculty of thinking:" we anſwer, no otherwiſe than he can endue a ſpirit with ſolidity and extenſion; that is, he can change ſpirit into matter: and he can change matter into ſpirit. But even the Almighty cannot make it think while it remains matter; becauſe this implies a contradiction.

12. The

12. The union of the ſoul and body is another of thoſe things which human underſtanding cannot comprehend. That body and ſpirit cannot be implicated or twiſted together like two bodily ſubſtances, we know. But how two ſubſtances of ſo widely different natures, can be joined at all, we know not. All we can tell is this; God has ordered that certain perceptions in the ſoul, ſhould conſtantly follow certain motions of the body, and certain motions of the body, ſuch perceptions in the ſoul.

13. How mankind began, is another point, which is too hard for our reaſon to determine. That men always exiſted, is no way probable, were it only on this account, the late invention of arts. For ſince it appears, at what time the moſt neceſſary arts were invented, we cannot reaſonably ſuppoſe, that men began to exiſt long before that period: ſeeing, if they had always exiſted, no reaſon can be given, why theſe and many more arts, were not invented long before. And yet the accounts given of the origin of mankind, by the wiſeſt of the heathen philoſophers, are ſo above meaſure ridiculous, that they ſerve as a melancholy proof of the weakneſs of barely natural reaſon.

14. The ſcriptural account is this: God made the body of man out of the earth, and breathed into him the breath of life: not only an animal life, but a ſpiritual principle, created to live for ever. Even his body was then perfect in its kind; neither liable to death nor pain. But what the difference was, between the original and the preſent body, we cannot determine.

But, to form it even as it is now, no leſs than a divine power was requiſite. No leſs could mix earth, water, air, and fire, in ſo exact a proportion, and then frame ſo many different parts, of ſo various figure, texture and magnitude. God alone was able to form the original fibres; to weave thoſe fibres into hollow tubes; to diſpoſe theſe tubes, filled with their ſeveral humours and variouſly interwoven with each other, into different organs; and of thoſe organs connected together

together in a continued ſeries and due ſituation, to finiſh ſo complicated and wonderful a machine as the human body.

15. Nothing was wanting now, but that the immortal Spirit ſhould be ſent into its habitation, to bear the image of its Creator, and enjoy his glory. But the manner wherein this was done we cannot tell: this knowledge is too wonderful for us. And it is of no uſe to indulge mere conjecture, where knowledge is unattainable.

16. Even the preſent production of the body by generation is what no man can fully explain. But this we know: the female ovaries, which hang on each ſide the womb, contain abundance of ſmall veſicles, filled with a tranſparent liquor. Some ſuppoſe, that each of theſe contains, in miniature, all the parts of a human body: that when one of them is penetrated by the male ſeed, it is rarified and expanded thereby, till it breaks the membranous ſhell, and by the fallopian tube, falls down into the womb. Here, being ſlightly faſtened to the ſides of the womb, it receives nouriſhment from the mother, till the heart is formed and begins to propel the blood to the extremities of the ſtill increaſing body. When it is come to its full ſize, by rolling to and fro, it tears aſunder the encloſing membranes, and having burſt as it were the priſon-bars, emerges into light.

The firſt thing that appears of a fœtus is the placenta, like a little cloud on one ſide of the outer coat of the egg. About the ſame time, the ſpine becomes viſible; and a little after, the brain and cerebellum appear like two ſmall bladders. Next the eyes ſtand prominent in the head: then the punctum ſaliens, the heart-beating is plainly to be ſeen; and laſt of all, the extremities. When formed, the fœtus lying in the womb, is almoſt of an oval figure. For the head hangs down with the chin upon the breaſt. Its back is round. With its arms it embraces the knees, which are drawn up to the belly, and its heels are cloſe to the buttocks. Its head is upward, and its face to the mother's belly. About the ninth month, the head, which till then was lighter,

lighter, becomes heavier than any other part. In conſequence of this, the head falls down in the liquor that contains it; the feet get looſe, and the face turns toward the mother's back. But being now in an uneaſy poſture, it ſtruggles and brings on the mother's throes.

Mr. Dodart, nicely obſerving an embryo, one and twenty days old, found the placenta more than half of the whole; and thence concludes the younger the embryo is, the larger is the placenta in proportion to it: a plain reaſon, why miſcarriages, though the fœtus is leſs, are more dangerous than regular deliveries. For though the embryo in a miſcarriage makes a way ſufficient for itſelf, it does not make a way for ſo large a placenta as is to follow it.

The embryo itſelf was only ſeven lines long, from the top of the head to the bottom of the ſpine, where it terminated. The thighs were not unfolded: they only appeared like two little warts at the bottom of the trunk. The arms made the ſame appearance on the ſhoulders. The head was one-third of the whole length. On this were two ſmall black points, which would have been eyes. The mouth was very big; a plain indication that it fed thereby. There was no eminence for the noſe; but two little, almoſt imperceptible pits for the noſtrils. Always the younger the embryo, the bigger the head is, in proportion to the body. The parts nearer the head are likewiſe bigger, in proportion to the reſt.

It weighed leſs than ſeven grains, which is an extraordinary lightneſs, for a body ſeven lines long. It was ſo ſoft, that no part of it could be touched, without making a change in its figure. Upon opening it, Mr. Dodart diſcovered the heart and the right auricle. All the other parts in the thorax and the lower belly, were ſimple outlines, (all veſicular) except a part on the left ſide, probably the ſpleen.

Some ſuppoſe, that millions of animalcula ſwim in the ſeed of male animals, which are ſo many embryos, for which a receptacle only is provided in the eggs of the female. But all agree, that either the male ſeed, or the female egg, contains all the parts of the body; ſo that generation is no more than the growth or unfolding

folding of the parts there delineated. But how thoſe ſeeds, whether male or female, are elaborated and prepared, abundantly tranſcends the higheſt reach of human underſtanding.

If the animalcula, of which all animals are formed, are originally in the male, yet they never can be formed into animals, without the egg of the female.

That all animals ſpring from animalcula, ſeems probable from the following conſiderations:

1. That ſomething may be obſerved in the tread of an egg, even before incubation, like the rudiments of an animal in form of a tadpole.

2. That after incubation, all the parts of the animal ſuddenly appear, the ſtamina, which exiſted before, being then expanded. After three days incubation, the punctum-ſaliens of a chick is diſcovered by the naked eye. On the fifth day, the rudiments of the head and body appear, which were before diſcernable by glaſſes. After thirty hours, we ſee the head, the eyes, the heart, and the carina, with the vertebræ diſtinct. And by glaſſes we ſee all thoſe parts, after forty hours, which the naked eye cannot diſcern till the fifth day. Whence it is probable, that even the firſt diſcovery of them by the microſcope, is not the diſcovery of the parts newly formed, but of thoſe that exiſted before incubation, though not then dilated enough to be viſible.

3. That there is a near analogy between animals and plants. Now we know, the ſeeds of theſe are only little plants, folded up in membranes. Hence we may eaſily infer, that animals proceed from animalcula folded up, till they are gradually enlarged and unfolded.

And that theſe animalcula are originally in the ſeed of the male, is probable. For 1. Numberleſs animalcula are obſerved in the ſeed of animals. 2. We obſerve the rudiments of a fœtus in eggs fecundated by the male, but not in others. 3. The rudiments in the egg, both before and after incubation, exactly reſemble

ble the animalcula in the ſeed. 4. This gives a rational account of many fœtuſes at one birth, eſpecially that of the Counteſs of Holland. It accounts alſo for a whole cluſter of eggs in a hen, being fecundated at once. 5. This beſt ſuits the analogy between animals and plants. Every herb and tree bears its own ſeed; and a little plant of the ſame kind, which being thrown into the womb of the earth, ſpreads forth its root and receives its nouriſhment from the earth, but has its form within itſelf.

Yet, that no animal can be formed without the egg of the female, is evinced by the following conſiderations.

1. No animalcula can come forward, if it do not fall into a proper nidus. So though a thouſand ſhould fall into one egg, none of them would come forward, but that which was in the very centre of the cicatricula, or tread. And perhaps the nidus neceſſary for their formation is ſo proportioned to their bulk, that it can hardly contain more than one animalcula. This is certainly the caſe in oviparous kinds. And all the difference between the viviparous and the oviparous is, that in the former, the egg is nothing but the cicatricula with its yolk: ſo that the fœtus muſt draw its nouriſhment from the womb. Whereas, in the oviparous, the egg itſelf, is a kind of womb, containing all that is needful for the animal, till it is hatched.

2. It is acknowledged, that the fœtus in the womb, is not connected with it, for a conſiderable time after conception: that it is wholly looſe from it, and is only a little round egg, with the embryo in the midſt, which ſends forth its umbilical veſſels by degrees, and at laſt lays hold on the womb. Hence it is plain, that the cicatricula, which nouriſhes the animalcula, does not ſpring from the womb, but only falls into it, as a fit ſoil, whence it may draw nouriſhment for the fœtus.

Yet there is a difficulty which preſſes equally on thoſe, who ſuppoſe the animal to ſpring either from the male or female parent. It is the caſe of monſters. In a mule, for inſtance: the body is of the form of the mare: whereas the feet, the tail, and the ears, reſemble thoſe of its ſire. If the male ſupplied the animal-

cula,

cula, one would imagine the fœtus ſhould always be of the ſame ſpecies with the male. If the female, it ſhould be of her kind: whereas monſters are of both: as if the main part of the animal lay in the egg, and the impregnation only conveyed or changed the extremities.

Yet, that ſome animals firſt exiſt, not in the ſeed of the male, but wholly in the egg of the female, undeniably appears from the caſe of frogs and toads. (And why may it not be the ſame thing with other animals?) The eggs of theſe are not impregnated by the male, till they iſſue from the womb. It is while they are ejected, that he fecundates them with his ſeminal liquor. And there is no circumſtance, by which the fecundated egg can be known from the unfecundated. It appears therefore, that tadpoles exiſt before fecundation. For the unfecundated eggs do not differ in the leaſt from thoſe that are fecundated. But theſe are only tadpoles coiled up. Such, therefore, are the unfecundated tadpoles: they exiſt before fecundation; only they cannot unfold themſelves without the liquid of the male. Frogs then ſhould not be placed among oviparous animals, but among viviparous: if they do not rather conſtitute a claſs between both. Thus nature ſeems to delight in diverſifying the modes of animal generation.

This may be the caſe with regard to one, or perhaps a few ſpecies of animals. But, in general, where to place the pre-exiſtent animal or embryo, in the animalcula or the egg, is ſtill the queſtion. A diviſion of vital, eſſential, and original ſtamina, is impoſſible. Yet innumerable inſtances in monſters, mules, and many natural ſubjects, concur to prove, that the young partakes of the nature and qualities of both the parents, even to their defects and diſeaſes, which are often hereditary. How then can we ſuppoſe unalterable ſtamina? Can the viſible ſpecies of any production be determined by them, if every ſenſible quality may be influenced indiſcriminately by either parent.

If they are placed in the animalcula or the egg, how are they tranſmitted? If in the animalcula, why is the

the proceſs attended with ſo vaſt an expense, ſo great a waſte of millions of entities, each containing a ſeries of the moſt perfect, and moſt wonderful productions, when one only of thoſe millions is to take place? And how are theſe animals generated? If in the common way, not only the proceſs will be boundleſs, (theſe in their ſeed will have others, and ſo on in an endleſs ſeries;) but they cannot then be unalterable, becauſe they are capable of being generated. Further, if they float in the air, or lie hid in the food, how is it that the ſtamina of one ſpecies does not ſometimes inſinuate themſelves into a parent of another ſpecies? Or if they are excluded, by proper ſtrainers, in diſtant ſpecies, they cannot be ſo in thoſe that are near a-kin. For if the ſpermatic animal, which in the matrix of a mare, produces a horſe, is yet ſo fitted to that of an aſs, that it can poſſeſs a cellule there, excluſive of every other, which ſhews an exact co-aptitude; certainly the ſame animal, if contained in food or air, common to both horſe and aſs, might paſs indiſcriminately the ſtrainers of either: and ſo we might have mules without the promiſcuous congreſs of the two ſpecies.

In another view, if we conſider the extreme tenuity of one of theſe ſtamina, in its firſt origin at the diſtance of many ages, compared to the ſmalleſt fibre of the animal it is ſaid to conſtitute: can ſo minute a filament ſerve as a ſubſtratum for a cylinder, comparatively immenſe? Can the terraqueous globe derive its preſent dimenſions, from the dilatation of an atom? Such is a muſcular fibre in its preſent ſtate, compared to what it was in its origin. Conſequently, what muſt have been the increaſe of extraneous matter, either by appoſition or incorporation, which is now as much a part of the fibre, as the original ſtamen? And if thus much can be mechanically aſſimilated, why not the whole formed by mechanical cauſes? Or why muſt ſo inſignificant a part of it, be ſuppoſed to be concreated with the univerſe?

The difficulty ſtill increaſes immenſely, if we look into the vegetation of plants, and the wonderful reproduction of the parts of the polypus, lobſters, and many

many other animals. The original ſtamina, how minute ſoever, queſtionleſs, are diffuſed through the whole production: ſince in this ſyſtem all animal and vegetable growth is made by developement only. But if diffuſed, then ſome or all may be loſt by ſucceſſive biſection. And if loſt, how can they be re-produced? If re-produced, how were they conſecrated with the univerſe? Theſe and a thouſand other difficulties can in no wiſe be evaded, but by multiplying ſuppoſition on ſuppoſition, which renders the hypotheſis ſo complex, as utterly contradicts the ordinary proceſs of nature.

It is more reaſonable to ſay, that ſo many ſecretory ducts, ſo many ſtrainers, ſo many preparatory veſſels in animals, and ſuch a curious diſpoſition in plants, for the continuation of every ſpecies, imply a digeſtion, ſecretion, and preparation of principles, invariably productive of every individual, when they fall into their reſpective matrixes, and find aliment proper to aſſimilate. Are not theſe principles contained in the nouriſhment taken by the parent plant or animal, the ſame that continually vegetate in it, and increaſe it till it is adult, then exuberate, while it is by new preparations fitted, invariably to propagate its kind? Elſe why this digeſtion? Why this ſecretion? Why ſo many ſtrainers, receivers, ducts and valves? And why is ſome food more productive of theſe principles than others?

And if every mixt body is made up by the combination of certain principles, we cannot doubt, but God may have eſtabliſhed forces in nature, by which ſuch principles may in certain circumſtances, be invariably united, without any danger of deviating, ſo as to render generation equivocal. And if every production in queſtion is a mixt body, we know that how various ſoever they are, a ſmall number of principles differently combined, will yield variety enough to produce them all. Thus we reduce nature to what it is ever found to be, ſimple in the beginning of its courſe, but afterwards, when it is diſtributed, magnificent beyond expreſſion.

Modern naturaliſts all agree, that every plant proceeds from its ſpecific ſeed; every animal from an egg, or ſomething analogous, pre-exiſting in its parent.

But

But what do we mean by ſeeds and eggs? Theſe in the common ſenſe of the words, are certain mixt bodies, that immediately furniſh thoſe productions. They are ſaid to contain not only the pre-exiſtent germ, but the fit nidus alſo, and aliment to be aſſimilated in proper circumſtances. They are therefore heterogeneous bodies, that coaleſe in a known time. And their principles are ſo far from being united at the creation, that they ſenſibly come together from diſtant places, in all hermaphrodite plants, and from different individuals in all thoſe ſpecies, where the male and female are diſtinct.

But it is in vain for us to lay down any certain rule, and to ſay to nature, "This is thy ſcheme; from this thou ſhalt not deviate." If ſhe makes it a law in many ſpecies, that every individual requires the co-operation of a male and female parent; ſhe has, at the ſame time, her hermaphrodites, both in plants and animals. And if in ſome hermaphrodites, the ſexes are ſo diſtinct, that ſhe ſeems not to deviate far from her primitive law; ſhe will, in another inſtance, that of the pucerons, act either with or without the co-operation of a male. Again: in ſome ſpecies, the female may be ſo impregnated, that the impregnation ſhall diffuſe itſelf to five or ſix generations. Yet again: in many kinds of polypes, generation proceeds without male or female, egg or ſeed. And farther ſtill; there are ſome ſpecies of polypes, where a whole family, (after branching out by real vegetation, as far as nature deſigns) jointly concur to furniſh one egg, as the ſource of a future progeny. If at laſt you reſolve to ſtand by this, that at leaſt every individual proceeds from a parent like itſelf; even this is overthrown by late experiments. For we have now a cloud of inſtances, of a claſs of beings hitherto unknown, wherein animals grow upon, are produced by, and in the ſtricteſt ſenſe of the word, brought forth from plants. Then, by a ſtrange viciſſitude, they become plants of another kind. Theſe again become animals of another, and thus on, for a ſeries farther than the utmoſt power of glaſſes can carry the moſt inquiſitive obſerver.

And

And as to the animalcula ſuppoſed to be diſcovered in the male ſeed, the microſcope diſcovers the ſame in the ſeminal liquor of females. Probably neither the one, nor the other are real animals, but only inanimate particles in ſtrong fermentation.

PART THE SECOND.

OF BRUTES.

CHAP. I.

OF BEASTS.

1. *The general Difference of Men and Beaſts, as to the Structure and Poſture of the Body.*
2. *Their Agreement.*
3. *Their Agreement and Diſagreement, as to the Head and Brain.*
4. *The Heart and Lungs.*
5. *The Eyes.*
6. *The Ears, Noſe, Teeth.*
7. *The Windpipe.*
8. *The Vegetative and Senſitive Motions in Brutes.*
9. *Of the Soul of Brutes.*
10. *Of ſome particular Sorts of Beaſts.*
11. *Some general Reflections.*

1. NEXT to man in the viſible creation are beaſts. ——And certainly, with regard to the ſtructure of the body, the difference is not extremely great, between man and other animals. Only in this, that the ſtature of man is erect, and his form more elegant; that no beaſt has the feet of a man, much

leſs

leſs a hand, ſo admirably fitted for every purpoſe: and laſtly, that no other animal has a brain, ſo large in proportion to its bulk as man. Concerning the prone poſture of their body we may obſerve two things; the parts miniſtring thereto, and the uſe thereof.

I. As to the parts, it is obſervable, that in all theſe creatures, the legs are made exactly conformable to their poſture, as thoſe of man are to his poſture: and farther, that the legs and feet are always admirably ſuited to the motion and exerciſe of each animal. In ſome they are made for ſtrength, to ſupport a vaſt unwieldy body: as in the elephant, which being a creature of ſuch prodigious weight, has its legs accordingly made like pillars. In others, they are made for agility and ſwiftneſs. So deers, hares, and ſeveral other creatures, have their legs very ſlender, but ſtrong withal, and every way adapted for quick motion. In ſome, they are formed only for walking and running; in others, for ſwimming too. Thus in the feet of the otter, the toes are all conjoined with membranes, as they are in geeſe and ducks. And in ſwimming it is obſervable, that when the foot goes forward in the water, the toes are cloſe; but when backward they are ſpread out: whereby they more forcibly ſtrike the water, and drive themſelves forward. In others, as moles, they are made for walking and digging: and in others, for walking and flying *. In ſome they are made more weak, for the plainer lands; in others, ſtiff and leſs flexible, † for traverſing ice and dangerous precipices. In ſome they are ſhod with rough and hard hoofs, in others with only a callous ſkin ‡. In the latter,

* The membranous wings of a bat are a prodigious deviation from nature's ordinary way. And ſo is the Virginian flying ſquirrel; whoſe skin is extended, in the nature of wings, between its fore-legs and body.

† The elks have legs ſo ſtiff and flexible, that they run on ice without ſlipping. And this is the way they take in winter, to ſave themſelves from the wolves.

‡ The goat, which generally dwells on mountains and rocks, and delights to walk on narrow ridges, and to take great and ſeemingly

ter, the feet are compoſed of toes: ſome ſhort, barely for going; ſome long, to ſupply the place of a hand; ſome armed with long and ſtrong talons, to catch, hold and tear the prey; and ſome fenced only with ſhort nails, to confirm the ſteps in running and walking.

II. 1. As the poſture of man's body is the fitteſt for a rational animal, ſo is the prone poſture of beaſts, the moſt uſeful to themſelves, and the moſt fit for the ſervice they perform to man.

2. But there is a wonderful agreement between the bodies of men and beaſts, not only with regard to the ſtructure, but alſo the uſe of the ſeveral parts. How they differ, will be mentioned hereafter.

3. The brain in them is of nearly the ſame ſtructure and conſiſtence as in man, and undoubtedly performs the ſame office, ſecreting the animal ſpirits (if ſuch there be) in order to ſenſation and muſcular motion in every part of the body. The cerebellum is nearly of the ſame ſhape in all. But the ſhape of the brain neceſſarily varies according to that of the head.

It is remarkable, that in man the head is of one ſingle form: whereas in the four-footed race it is as various as their ſpecies. It is in ſome, ſquare and large, ſuitable to their food, abode, and ſlow motion: in others, it is ſmall, ſlender and ſharp, agreeable to their ſwifter motion, or to make way to their food, or habitation under ground. And as to the brain contained therein, how ſmall is it in beaſts, in proportion to what it is in man! Another thing no leſs remarkable is, the ſituation of the brain and the cerebellum. As God has given to man a lofty countenance, and has lodged in his brain an immortal ſoul, to behold and contemplate heavenly things, ſo as his face is erect, his brain is ſet in a higher place, above the cerebellum and all the ſenſories. But in brutes, whoſe face is prone to the earth, and who are not capable of ſpeculation,

seemingly dangerous leaps, has the joints of the legs remarkably stiff and strong. Likewise the hoof is hollow underneath, and its edges sharp.

the cerebelleum, which miniſters merely to animal life, is placed above the brain. Alſo ſome of the organs of ſenſe, are placed, if not above the brain, at leaſt on a level therewith.

Another very great inconvenience in this poſition of the brain and cerebellum is, in the head of man, the baſe of the brain and cerebellum, yea of the whole ſcull, is ſet parallel to the horizon: by which means there is the leſs danger of the two brains joggling or ſlipping out of the place. But in beaſts, whoſe heads hang down, the baſe of the ſcull makes a right angle with the horizon. By which means the brain is beneath, and the cerebellum above. And leſt the cerebellum ſhould hereby be liable to frequent concuſſions, an admirable proviſion is made, by that ſtrong membrane, the dura mater, cloſely encompaſſing it. Beſide this, it is guarded in ſome ſpecies with a ſtrong bony fence. In the hare, the coney, and ſeveral others, a part of the cerebellum is on each ſide within the os petroſum. So that its whole maſs is, by this double ſtay, firmly contained within the ſcull.

4. The heart and lungs in beaſts are of the ſame ſtructure, with the ſame apparatus of veins and arteries, as in men. We cannot therefore doubt but the blood circulates in them, and nutrition is performed as in us. Their food alſo being diſſolved in the ſtomach, is conveyed by the lacteals to the receptacle of the chyle. To the fore-part of this, (in men the upper part) joins the thoracic duct, which extending through the length of the thorax, ends in the vein, called in beaſts, cruralis anterior. The remaining part of the circulation is performed in them, as in men.

But ſome beaſts have more ſtomachs than one. And ſome have the peculiar property of chewing the cud. The food, after it has been ſwallowed, is returned to the mouth, where it is chewed over again at leiſure.

Not that this is altogether peculiar to beaſts. There have been inſtances of men who had this property. Dr. Slare gives us a particular account of one whom he knew at Briſtol. "He begins," ſays he, "to chew his meat over again, within a quarter of an hour after meals. This chewing, after a full meal, laſts an hour and

and a half. If he goes to bed ſoon after a meal, he cannot ſleep, till the uſual time of chewing be over. The victuals returned, taſte more pleaſantly than they did at firſt. Bread, fleſh, cheeſe and drink, are of much ſuch a colour, as they would be, if mixt together in a mortar. His victuals lie heavy on his ſtomach, till they have paſſed this ſecond chewing. He was thus ever ſince he can remember. His father does the ſame, but in ſmall quantities."—What a mercy is it, that we have not more ſuch inſtances! For how much of our precious time would it conſume!

5. The ſituation, number, and conformation of the eyes in various animals, is wonderfully adapted to their various circumſtances. In ſeveral, the eye looks chiefly forward, but ſo as to take in nearly the hemiſphere before it. In others, the eyes are ſo placed, as to take in nearly a whole ſphere. In ſome, they are ſo fixt as to look chiefly behind, ſo that they ſee their enemy following them. So in rabbits and hares: whereas in dogs they are more forward, to look after their prey.

Generally the head is moveable for the ſake of the eyes, and the eyes themſelves moveable every way. Where it is not ſo, other expedients are found, to anſwer the ſame end. Thus in ſome creatures, the eyes are ſet at a diſtance from the head, to be moved this way or that; as in ſnails, whoſe eyes are fixed to the end of their horns, or rather of the optic nerves which are ſheathed therein. In other creatures, whoſe heads and eyes are immoveable, this is made up by the number of eyes. So ſpiders, which cannot move their head, have four, ſix, or eight eyes, all placed in the front of the head, (which is round) like a locket of diamonds.

Many animals have muſcles to move the eye, and obvert it to the object. Fiſhes have none; but for amends, they have many little protuberances finely ranged on their large, bulging eyes; by which numberleſs rays of light are deflected from objects above, beneath, and on either ſide. Yea, ſome hundreds of theſe protuberances are curiouſly ranged on the convex eye of a fleſh-fly.

Scorpions have above a hundred eyes; an ephemeron-fly full two thouſand.

In other creatures, which have only two eyes, the want of motion thereby is ſupplied, by their eyes protuberating into hemiſpheres, each being a vaſt number of ſegments of a ſphere.

The eyes of a cameleon reſemble a convex glaſs ſet in a round ſocket, which he turns backward and forward without ſtirring the head, and commonly one a contrary way to the other.

Laſtly, moles living under ground, have not ſo much need of eyes as other creatures. Yet they have eyes, but exceeding ſmall, far in the head, and covered with ſtrong hair. When they are above ground they can put them forth beyond the ſkin, and draw them back at pleaſure.

Another circumſtance, relative to the eye, is highly remarkable. As we uſe various apertures to our optic glaſſes, ſo nature has made a far more complete proviſion, to admit enough, and not too much light, into the eyes of animals, by the dilatation and contraction of the pupil. And this, in divers animals of divers forms, is according to their peculiar occaſions. In ſome it is round, particularly in man, that being the moſt proper figure, for the poſition of our eyes, and the uſe we make of them, both by day and night. In ſome animals it is of a longiſh form, in ſome tranſverſe, with its aperture large, (an admirable proviſion for their ſeeing ſide-ways) and thereby avoiding many inconveniences, as well as a help for gathering their food on the ground, whether by day or night. In others, that aperture is erect, and alſo capable of opening wide and ſhutting cloſe. The latter ſerves to exclude the bright light of the day, the former to take in the faint rays of the night: thereby enabling them to ſee and catch their prey, when there is no light diſcernable to us.

Thus cats can ſo cloſe their pupil, as to admit but a ſingle ray of light. And again, by throwing all open, they can take in all the fainteſt rays: which is an incomparable proviſion for creatures that have occaſion to watch their prey both by day and night.

But

But beſide this, in cats and other nocturnal animals, there is a ſort of carpet at the bottom of the eye, which gives a kind of radiation on the pupil, thereby enabling them to ſee in the dark.

To preſerve this tender organ, many creatures have a membrane, which is not commonly perceived, wherewith they can at pleaſure cover the eye, without too much hindering the ſight; being both tranſparent and ſtrong, ſo that it is a kind of moveable cornea.

Providence is conſpicuous in furniſhing frogs with this. For as they live in watry places, which generally abound in plants that have ſharp edges or points; and as the frog goes on, not by walking but by leaping, if he were not ſo furniſhed, he muſt either ſhut his eyes, and ſo leap blindfold, or run many riſques by leaving them open. But this membrane guards the eyes, without blinding him. And as ſoon as the occaſion for it is over, he draws it back into a little cell.—Many birds alſo, as they muſt fly between trees and buſhes, are provided with the ſame membrane. And ſo is the rein-deer.

6. The comparative anatomy of the ear, yields abundant inſtances of the Creator's wiſdom. In birds the outward ear is cloſe and covered, not protuberant, as that would obſtruct their flight. In beaſts, its form is agreeable to the poſture and motion of the body, but admirably varied in the ſeveral ſpecies, according to their various occaſions. In ſome, as the hare, it is large, open, and erect: by which means that timorous, helpleſs creature, is warned of the leaſt approach of danger. In others, it is covered to keep out noxious bodies. In thoſe which are forced to mine and dig for their habitation, it is ſhort, and lodged deep and backward in the head. Thus moles have no auricle at all; but only a round hole, between the neck and ſhoulder. And this is cloſed with a little ſkin, which opens and ſhuts like an eye-lid.——The ſea-calf alſo, as well as lizards, and ſerpents have no outward ear. And the tortoiſe, with moſt kinds of fiſhes, have the paſſage quite covered over.

But among all the varieties in the ſtructure of this organ, none are more remarkable than thoſe of the

paſſage

paſſage into the os petroſum. In an owl, which perches upon a tree or beam, and hearkens after the prey beneath her, it comes farther out above than below, for the better reception of ſounds from beneath. In a fox, which ſcouts under the prey at rooſt, it comes farther out below than above. In a pole-cat, which hearkens ſtraight forward, it is produced behind, for the taking a forward ſound. Whereas a hare, whoſe enemy comes behind, is ſupplied with a bony circle, directed backward: by means of which ſhe receives diſtinctly the ſmalleſt ſound which comes that way.

The more accurate the ſenſe of ſmelling is in any creature, the longer are the laminæ in the noſtrils, and the more in number, folded up, and crowded together, to contain more nervous filaments, and to detain the odoriferous particles, in their windings and turnings. An admirable proviſion this, for the good of many creatures, the chief acts of whoſe lives are performed by the miniſtry of this ſenſe. In inſects and many other creatures it is of great uſe, in helping them to proper places for hatching their eggs, and breeding up their young. And moſt irrational animals, beaſts, birds and reptiles, do by their ſmell find out their food. With what ſagacity do ſome of them diſcover it, in the midſt of mud and dirt? How curiouſly do others pick and chuſe ſuch plants as afford them wholeſome food, (perhaps medicine too) avoiding ſuch as tend to hurt or deſtroy them? And all this principally by the ſmell, together, with its near ally, the taſte.

The various forms of the teeth in various creatures, is another inſtance of the divine wiſdom. How curiouſly are they adapted to the peculiar food and occaſion of each ſpecies? Thus in the rapacious, they are fitted to catch and hold their prey; in the herbaceous, to gather and chew vegetables. In thoſe which have no teeth, as birds, the bill ſupplies that defect; together with their additional ſtomach. And it is a remark which hardly fails, all ſuch animals as have four ſtomachs, have no teeth at all.

There are great varieties in the teeth of other animals. Trout have teeth upon their tongues; cod-fiſh at the bottom of their gullet. Crocodiles have three rows of teeth on the ſame jaw; ſharks, four or five;

ſea-

ſea-devils, (ſo called), have ſeveral rows of moveable teeth.

7. The variation of the wind-pipe, in various creatures, is likewiſe obſervable, as it is neceſſary for that of the voice. In a hedge-hog, which has a very ſmall voice, it is hardly more than membranous. In a pigeon, which has a low, ſoft note, it is partly membranous, partly cartilaginous. In an owl, which has a good audible note, it is more cartilaginous. But that of a jay (as of a linnet) has bones inſtead of cartilages.

The rings of the wind-pipe likewiſe are fitted for the modulation of the voice. For in dogs and cats, which uſe a great many notes, they are (as in man) open and flexible: whereby all or any of them is more or leſs dilated or contracted, in order to a deeper or ſhriller note. But they are one entire ring in the Japan-peacock, which uſes one ſingle note.

8. As to the motions of brutes, it is not eaſy to conceive, that even thoſe of the vegetative kind, can be the mere mechanical effects of matter, however modified. Much leſs can we conceive this of their ſenſitive motion: for we have not the leaſt reaſon to doubt, but the ſame impreſſions of external objects, raiſe the ſame perceptions in them, as in us.—No queſtion, they ſee, and hear, and ſmell, and taſte, and feel in the ſame manner as men!

9. We cannot therefore deny, that there is ſomething in brutes, which perceives the impreſſions made by outward objects; and that they perform a thouſand actions, which can never be explained by mere mechaniſm: thoſe in particular which ſpring from what we call inſtinct, as the feeding and tending their young, the building their neſts and preparing their habitation, upon or in the earth.

It is true, ſome things in brutes, as well as in men, may be mechanically accounted for. But others cannot: ſo that we are conſtrained to own, there is in them alſo ſome ſuperior principle, of whatever kind it be, which is endued with ſenſe, perception and various appetites.

petites. For from their outward actions we may as eaſily learn, as we could from thoſe of a man born deaf and dumb, that there are in this principle or ſoul two different faculties: that of perceiving or knowing, anſwerable to our underſtanding; and that of deſiring and ſhunning, anſwerable to our will. That this principle is immaterial, appears from this ſingle conſideration, it has a power of ſelf-motion; which no matter can have, being wholly and eſſentially paſſive.

10. It is not my deſign to enumerate the ſeveral ſpecies of beaſts. But it may illuſtrate the wiſdom of the great Creator, to give ſome account of a few; ſeveral of which are not ſo commonly known.

The largeſt land-animal in the world is an elephant, which ſeems rather to belong to the hog-kind than any other. They are found only in the ſouth of Africa, and in the Eaſt-Indies, and are generally of a dark colour. Their eyes are like thoſe of a hog. At the corners of their mouth grow two large teeth, ſix or ſeven feet long in the male, but not above one in the female. They feed on graſs, nuts, and other vegetables.

Of all quadrupeds, the elephant is the ſtrongeſt, as well as the largeſt; and yet in a ſtate of nature, it is neither fierce nor formidable. Mild, peaceful, and brave: it never abuſes its ſtrength, and only uſes it for its own protection. In its native deſarts, the elephant is a ſocial, friendly creature. The oldeſt of the company conducts the band; that which is next in ſeniority brings up the rear. The young, the weak, and the ſickly, fall into the centre; while the females carry their young. They maintain this order only in dangerous marches, or when they deſire to feed in cultivated ground: they move with leſs precaution in the foreſts, and ſolitudes; but without ever removing far aſunder.

Nothing can be more formidable than a drove of elephants, as they appear at a diſtance, in an African landſcape: wherever they march, the foreſt ſeems to fall before them; in their paſſage they bear down the branches, on which they feed; and if they enter into an encloſure, they deſtroy all the labours of the huſbandman, in a very ſhort time. Their invaſions are

the

the more diſagreeable, becauſe there is no means of repelling them: ſince it would require a ſmall army to attack the whole drove when united. It now and then happens, that one or two is found lingering behind the reſt, and it is againſt theſe that the art and force of the hunters are united; but an attempt to moleſt the whole body, would certainly prove fatal. They go forward directly againſt him who offers the inſult, ſtrike him with their tuſk, ſeize him with their trunks, fling him into the air, and then trample him to pieces under their feet. But they are thus dreadful, only when they are offended, and do no manner of perſonal injury, when ſuffered to feed without interruption.

The elephant has very ſmall eyes, when compared to the enormous bulk of its body. But, though their minuteneſs may at firſt ſight appear deformed, yet, when we come to examine them, they are ſeen to exhibit a variety of expreſſion. It turns them with attention and friendſhip to its maſter; it ſeems to reflect and deliberate; and as its paſſions ſlowly ſucceed each other, their various workings are diſtinctly ſeen. It is remarkable for the excellence of its hearing. Its ears are extremely large. They are uſually dependent; but it can readily raiſe and move them. They ſerve alſo to wipe its eyes, and to protect them againſt the duſt and flies. It appears delighted with muſic, and readily learns to beat time, to move in meaſure, and even to join its voice with the drum and trumpet.

This animal's ſenſe of ſmelling is not only exquiſite, but it is pleaſed with the ſame odours that delight mankind. The elephant gathers flowers with great pleaſure; it picks them up one by one, unites them in a noſegay, and ſeems charmed with the perfume. The orange-flower is particularly grateful, both to its taſte and ſmell; it ſtrips the tree of all its verdure, and eats every part of it, even to the branches themſelves. It ſeeks in the meadows the moſt odoriferous plants to feed upon; and in the woods it prefers the cocoa, the banana, the palm, and the ſage tree to all others.

But it is in the ſenſe of feeling, that this animal excels all others of the brute creation, and perhaps man himſelf. The organ of this ſenſe is wholly in the trunk,

which is an inſtrument peculiar to this animal; and that ſerves it for all the purpoſes of a hand. The trunk ends in two openings, or noſtrils, like thoſe of a hog. An elephant of fourteen feet high, has the trunk about three feet long, and five feet and a half in circumference, at the mouth. It is hollow all along, but with a partition running from one end of it to the other. This tube is compoſed of nerves and muſcles covered with a ſkin like that of the reſt of the body. It is capable of being moved in every direction, of being lengthened and ſhortened, of being bent or ſtraightened; ſo pliant as to embrace any body it is applied to, and yet ſo ſtrong that nothing can be torn from its gripe. To aid the force of this graſp, there are ſeveral very little eminences, like a caterpillar's feet on the under-ſide of this inſtrument, which without doubt contributes to the ſenſibility of the touch as well as the firmneſs of the hold. Through this trunk the animal breathes, drinks and ſmells; and at the very point of it, juſt above the noſtrils, there is an extenſion of the ſkin, above five inches long, in the form of a finger, and which, in fact, anſwers all the purpoſes of one; for with the reſt of the extremity of the trunk, it is capable of aſſuming different forms at will, and, conſequently, of being adapted to the minuteſt objects. By means of this, the elephant can untie the knots of a rope, unlock a door, and even write with a pen. It ſometimes happens, that the object is too large for the trunk to graſp; in ſuch a caſe the elephant makes uſe of another expedient. It applies the extremity of the trunk to the ſurface of the object, and, ſucking up its breath lifts and ſuſtains ſuch a weight as the air in that caſe is capable of keeping ſuſpended. In this manner this inſtrument is uſeful in moſt of the purpoſes of life; it is an organ of ſmelling, of touching, and of ſuction; it not only provides for the animal's neceſſities, but it alſo ſerves for ornament and defence.

The legs are not ſo inflexible as the neck, yet they are very ſtiff, and bend not without difficulty. Thoſe before, ſeem to be longer than the hinder; but, upon being meaſured, are found to be ſomething ſhorter. The joints by which they bend are nearly in the middle,

dle, like the knee of a man, and the large bulk which they are to ſupport, makes their flexure ungainly. Yet while the elephant is young, it bends the legs to lie down or riſe; but when it grows old, or ſickly, this becomes ſo inconvenient that the animal chuſes to ſleep ſtanding.

It is one of the ſtriking peculiarities of this animal, that his generative powers totally fail when he comes under the dominion of man; as if he ſeemed unwilling to propagate a race of ſlaves to increaſe the pride of his conqueror.

The elephant, when once tamed, becomes the moſt gentle and obedient of all animals. It ſoon conceives an attachment for the perſon that attends it, careſſes him, obeys him, and ſeems to anticipate his deſires.

In a ſhort time it begins to comprehend the ſigns made to it, and even the different ſounds of the voice; it perfectly diſtinguiſhes the tone of command from that of anger or approbation, and acts accordingly. It receives its orders with attention; eagerly, yet without precipitation. All its motions are regulated, and its actions ſeem to partake of its magnitude, being grave and majeſtic. It is quickly taught to kneel down to receive its rider; it careſſes thoſe it knows with its trunk; with this ſalutes ſuch as it is ordered to diſtinguiſh, and with this, as with a hand, helps to take up part of its load. It ſuffers itſelf to be arrayed in harneſs; and ſeems to take a pleaſure in the finery of its trappings. It draws either chariots, cannons, or ſhipping, with ſurpriſing ſtrength and perſeverance; and this with a ſeeming ſatisfaction, provided its maſter appears pleaſed with its exertions. And he frequently takes ſuch an affection for his keeper that he will obey no other: and it has been known to die for grief, when in ſome ſudden fit of madneſs, it has killed its conductor.

In Deli, an elephant paſſing the ſtreets, put his trunk into a taylor's ſhop, where ſeveral people were at work. One of the perſons of the ſhop deſirous of amuſement pricked the animal's trunk with his needle. The elephant paſſed on without any ſigns of reſentment, but coming to a puddle of dirty water, filled

his

his trunk, returned to the ſhop, and ſpurted it over all their finery.

Some of them are twenty feet in compaſs, and near fourteen high. They ſeem to have more ſenſe than any other brute, and are capable of fidelity and ſtrong affection: particularly to their companion: ſo that neither the male nor female is ever known to make a ſecond choice.

The female goes ſeventeen months with her young: they are fifty or ſixty years before they have their full ſtrength, are in full vigour about a hundred, and live two or three hundred years.

A rhinoceros, next to the elephant, is the moſt extraordinary animal in the Indies. It is uſually twelve feet long, from the tip of the noſe to the inſertion of the tail; from ſix to ſeven feet high; and the circumference of its body is nearly equal to its length. It is therefore equal to the elephant in bulk, and if it appears much ſmaller to the eye, the reaſon is, the legs are much ſhorter. In other reſpects it is ſhaped like a wild-boar.

It is ſaid to have a very rough tongue, but this is ſo far from the truth, that no animal of near its ſize has ſo ſoft a one. It is ſmooth and ſmall like that of a dog; and to the feel, it appears as if one paſſed the hand over velvet. It has a peculiar cry, a mixture between the grunting of a hog, and the bellowing of the calf.—The age of theſe animals is not well known: it is ſaid by ſome, that they bring forth at three years old, and if we may reaſon from analogy, it is probable they ſeldom live above twenty.

That which was ſhewn in London, was ſaid by its keeper, to be eighteen years old, and even at that age, he pretended to conſider it as a young one; however it died ſhortly after, and that probably in the courſe of nature. It is a native of Aſia and Africa, and is uſually found in thoſe extenſive foreſts that are frequented by the elephant and lion. As it ſubſiſts entirely upon vegetable food, it is peaceful and harmleſs among its fellows of the brute creation; but though it never provokes to combat, it equally diſdains to fly.

It

It is every way fitted for war, but reſts contented in the conſciouſneſs of its ſecurity.

His ſkin is without hair, and ſo full of ſcratches and ſcabs, that at a diſtance they may well be taken for ſcales. On his noſe he has a horn of a dark brown colour, which bends backward, and is often two feet long. He has often another horn a little above this, which never exceeds ſix inches. His eyes are exceeding ſmall, and he only ſees ſtrait forward: therefore he always runs in a ſtrait line, tearing up whatever ſtands in his way. With his horn he throws ſtones over his head to a great diſtance, and even tears up trees by the roots.

The outer ſkin of the rhinoceros, which conſiſts of many folds, is thick and impenetrable. In running one's fingers under one of the folds, it feels like a piece of board half an inch thick. But between the folds the ſkin is as ſmooth and ſoft as ſilk, and eaſily penetrated.—See here the wiſdom of the great Creator! If the outer ſkin, which is quite inflexible, was continued all over him without any fold, he could not perform any action whatever. But the ſuppleneſs of the ſkin in other beaſts, is compenſated in this by theſe folds. It was neceſſary his ſkin ſhould be hard for his defence: mean time it was a noble contrivance, that it ſhould be ſo ſoft and ſmooth underneath, that when he bends himſelf any way, one part of this board-like ſkin, ſhould ſlide over the other. And theſe folds are placed in ſuch parts of his body, as to facilitate the performance of every voluntary motion.

Another native of the Eaſt-Indies is the camel, one of the moſt ſerviceable animals in the world. He kneels down to receive his burden, and riſes when he hath his accuſtomed load. If he feels himſelf overburdened he will not riſe, but cry till part of it is taken off. One of them will carry a thouſand or twelve hundred weight, forty miles a day, for thirty or forty days together. They have no teeth in the upper jaw. They will travel forty hours, without either meat or drink: and nine days without drink: they have two ſtomachs admirably contrived for this purpoſe. The gentleman who diſſected one at Paris, found in his ſecond

cond ſtomach ſeveral ſquare holes, which were the orifices of about twenty cavities, made like ſacks, placed between the two membranes, which compoſe the ſubſtance of the ſtomach. And in theſe reſervoirs he contains water enough to ſerve him for ſo many days.

The bunch on his back is not fleſh, much leſs bone, but mere hair. And when this is preſſed cloſe down, he is no more hunch-backed than a ſwine. They ſubſiſt on very little, which enables them to travel through thoſe vaſt and barren deſerts.—How wiſe is He who cauſed theſe to be natives of thoſe countries, where ſuch creatures are abſolutely neceſſary! A farther inſtance of this is, that the African camel, which has ſtill greater and more uncouth journeys to take, is larger and ſtronger, and capable of carrying heavier burdens than thoſe of Aſia.

Another wonderful property of camels is, that of foreſeeing the poiſonous winds, which kill in a moment. A little before theſe come, they run together and cry, and hide their noſes in the earth. And as ſoon as they are paſt, they lift up their heads, and continue their journey.

The dromedary in moſt reſpects reſembles the camel; only it is of a ſlighter make, and inſtead of one bunch on its back, has two, about ſix inches in height. It goes frequently forty leagues a day; ſo that although it cannot carry above ſix hundred weight, yet its ſwiftneſs atones for its weakneſs. Its feet are ſoft as a ſponge, and are not hurt, either by ſtones or ſand. And (what is an excellent providence) they travel beſt, and have the greateſt ſpirits in the hotteſt weather.

The lamas in Peru, have ſmall heads, reſembling in ſome meaſure both a horſe and a ſheep. The upper lip is cleft, like that of a hare, through which, when they are enraged, they ſpit, even to ten paces diſtance, a ſort of juice, which when it falls upon the ſkin, cauſes a red ſpot and great itching. The neck is long, like that of a camel, the body like that of a ſheep, but with much longer legs. It yields ſtrong and fine wool,

and

and is alſo a beaſt of burden, and kept at an eaſy expense. It carries a burden a vaſt way, without tiring; eats very little, and never drinks. At night he lies down, and no blows can make him riſe, or move one foot till morning.

A creature no leſs remarkable, but in a quite different way, is the caſtor or beaver. This creature is about four feet long, and fifteen inches broad. He is covered with two ſorts of hair, one long, the other a ſoft down. The down, an inch long, is properly his clothing, being extremely fine, and cloſe laid upon the ſkin. The long hair is ſpread over all, to preſerve it from dirt and wet.

Whether male or female, it has two bags under its belly, which contain a liquid ſubſtance, that congeals in air, and affords an excellent medicine, which we call caſtoreum.

He has ſtrong teeth riveted faſt in his jaws, to cut wood, as well as chew his food. His fore-feet are like thoſe of an ape or ſquirrel, to hold what he eats in his paw. And with theſe he digs, ſoftens and works the clay or loam for his habitation. His feet are remarkably formed, more proper to ſwim than to walk with, the five toes being joined together by a ſtrong membrane. His tail is long, flattiſh, covered with ſcales, and conſtantly lubricated with oil; becauſe, being an architect from his birth, he uſes his tail as a hod, to carry his clay or mortar, and as a trowel, to ſpread it into an incruſtation. Mean time the ſcales preſerve it from being hurt by the burden; and the oil which he ſqueezes from his bags, and rubs on with his ſnout, from the noxious air and water.

As they like to live together, they chuſe a ſituation near ſome rivulet. They firſt build a cauſeway, in which the water may riſe level with the firſt ſtory of their habitation. This is built of wood and clay, twelve feet thick at the bottom, deſcending in a ſlope on the ſide next the water. The other ſide is perpendicular: the top of this is about two feet broad. They cut their wood, though as thick as one's thigh, into pieces, from two to ſix feet long, drive them into the earth with their teeth, and lace them together with boughs,

cloſing

cloſing all the opening within and without with a ſtrong plaiſter made of clay. If the water increaſe upon them, they raiſe their wall higher. Knowing their materials are more eaſily brought by water than by land, they watch its increaſe, to ſwim with mortar on their tails, and ſtakes between their teeth to the place where they build. When the cauſeway is finiſhed, they begin their apartments, which are oval, and divided into three partitions, one above another. But the walls of theſe are perpendicular, and only two feet thick. All the wood that projects, they cut off with their teeth: and rough-caſt both the out and inſide of their work, with a mixture of clay and dry graſs. The firſt partition being below the level of the dyke, is full of water; for they love to have their hinder part hanging in the water. The other two are above it, ſo that if the water aſcend, they may aſcend proportionably.

At the bottom of their building, they ſtrike out two openings to the ſtream: one leads to the place where they bathe, the other to that where they eaſe nature.

They aſſociate ten or twelve together, and proportion their houſe to their number. When all is finiſhed below, they vault the top or roof in an oval form.

In ſummer they feed on fruits and plants: in winter, on willow, aſh, or other wood. This they collect and ſtore up in time. They cut boughs from three to ſix feet long: the large pieces are brought to the magazine by ſeveral beavers, the ſmaller by one alone; but they take different ways, each having his path aſſigned, to prevent the labour being interrupted. They build up their pile with much art, which is proportioned to their number. A ſquare pile of thirty feet, about ten feet deep, ſerves for ten beavers. But the wood is not piled up in one continued heap: the pieces are laid acroſs one another, with cavities between, for the conveniency of drawing out what they want. They always uſe firſt the parcel at bottom, which lies in the water. And when it is taken up for uſe, they cut this wood into ſmall pieces, and convey it to their apartment, where the whole family come and receive their ſhares.

The feet of a female beaver, which a gentleman kept in England ſome years ſince, were webbed, like thoſe

of

of a gooſe. The tail was ſcaly, and ſhaped like the blade of an oar. This ſhe uſed as a rudder to ſteer herſelf, eſpecially when ſhe ſwam under water, which ſhe would do for two or three minutes, and then come up to take breath, ſometimes raiſing only her noſtrils above water. She ſwam ſwifter than any water fowl; and under water as ſwift as a carp. The hind legs being longer than the fore, make her walk ſlow on dry land, or rather waddle like a duck. If drove along faſt, ſhe could not run, but went by jumps, ſlapping her tail againſt the ground. She never made any noiſe, except a little ſort of a grunting, when angry, or driven faſt.——As the beaver frequents the water like water fowls, may not the caſtor be provided for him by nature, to anoint his fur with, and prevent the water from ſoaking to his ſkin. And as it is impregnated with penetrating, pungent particles, it may likewiſe contribute to keep off the chill, which the water might otherwiſe ſtrike to his body, when he remains long therein.

The ſhammoy, though a wild animal, is eaſily tamed, and is to be found only in rocky and mountainous places. It is about the ſize of a domeſtic goat. It is agreeably lively, and active beyond expreſſion. The ſhammoy's hair is ſhort, like that of the doe. In ſpring it is of an aſh-colour; in autumn, a dun colour, inclining to black; and in winter, of a blackiſh brown. This animal is found in great plenty in the mountains of Dauphiny, of Piedmont, Savoy, Switzerland, and Germany. They are peaceful, gentle creatures, and live in ſociety with each other. They are found in flocks of from four to fourſcore, diſperſed upon the crags of the mountains. The large males are ſeen feeding detached from the reſt, except in rutting time, when they approach the females, and drive away the young.

It is to be obſerved, that this creature is extremely vigilant, and has an eye the moſt piercing in nature. Its ſmell alſo is not leſs diſtinguiſhing. When it ſees its enemy diſtinctly, it ſtops for a moment; and then if the perſon be near, in an inſtant flies off. In the ſame manner it can by its ſmell, diſcover a man at a great

great diſtance, and gives the earlieſt notice. Upon any alarm, the ſhammoy begins his hiſſing note with ſuch force, that the rocks and the foreſts re-echo to the ſound. The animal having repoſed a moment, again looks round, and perceiving the reality of its fears, continues to hiſs by intervals. During this time, it ſeems in the moſt violent agitation; it ſtrikes the ground with its fore-foot, and ſometimes with both: it bounds from rock to rock; it turns and looks round; it runs to the edge of the precipice, and ſtill flies with all its ſpeed.

Its head is furniſhed with two ſmall horns, of about half a foot long, of a beautiful black. The ears are placed in a very elegant manner, near the horns; and there are two ſtripes of black on each ſide of the face, the reſt being of a whitiſh yellow, which never changes. They run along the rocks with great eaſe and indifference, and leap from one to another, ſo that no dogs are able to purſue them. They always mount or deſcend in an oblique direction; and throw themſelves down a rock of thirty feet, and light with great ſecurity upon ſome excreſcence or fragment, on the ſide of the precipice, which is juſt large enough to place their feet upon. The more craggy and uneven the foreſt, the more this animal is pleaſed with the abode, which thus adds to its ſecurity.

The roe-buck is the ſmalleſt of the deer-kind in our climate, and is now almoſt extinct, except in the Highlands of Scotland. It is generally about three feet long, and about two feet high. The horns are from eight to nine inches long, upright, round, and divided into three branches. The body is covered with very long hair, well adapted to the rigor of its mountainous abode.

As the ſtag frequents the thickeſt foreſts, and the ſides of the higheſt mountains, the roe-buck courts the ſhady thicket, and the riſing ſlope. Although far inferior in ſtrength to the ſtag, it is more active, and even more courageous. Its hair is always ſmooth, clean, and gloſſy; and it frequents only the dryeſt places, and of the pureſt air. Though but a very little animal, yet, when its young are attacked, it faces

the

the ſtag himſelf, and often comes off victorious. All its motions are elegant and eaſy; it bounds without effort, and continues the courſe with little fatigue. It is alſo poſſeſſed of more cunning in avoiding the hunter; and, although its ſcent is much ſtronger than that of the ſtag, it is more frequently found to make good a retreat. The ſtag never offers to uſe art until his ſtrength is beginning to decline: this more cunning animal, when it finds that its firſt efforts to eſcape are without ſucceſs, returns upon its former track, again goes forward, and again returns, until by its various windings, it has entirely deſtroyed the ſcent, and joined the laſt emanations to thoſe of its former courſe. It then by a bound, goes to one ſide, lies flat upon its belly, and permits the pack to paſs by very near, without offering to ſtir.

The roe-buck differs from the ſtag alſo, in its natural appetites, its inclinations, and its whole habit of living. Inſtead of herding together, theſe animals live in ſeparate families; the ſire, the dam, and the young ones aſſociate together, and never admit a ſtranger into their little community. All others of the deer-kind are inconſtant in their affection; but the roe-buck never leaves its mate; and as they have been generally bred up together, from their firſt fawning, the male and female never after ſeparate.

They drive away their fawns upon theſe occaſions; the buck forcing them to retire in order to make room for a ſucceeding progeny. However, when the ſeaſon is over, the fawns return to their does, and remain with them ſome time longer; after which, they quit them entirely, in order to begin an independent family of their own.

When the female is ready to bring forth, ſhe ſeeks a retreat in the thickeſt woods, being not leſs apprehenſive of the buck, from whom ſhe then ſeparates, than of the wolf, the wild cat, and almoſt every ravening animal of the foreſt. She generally produces two at a time. In about ten or twelve days theſe are able to follow their dam, except in caſes of warm purſuit, when their ſtrength is not equal to the fatigue. Upon ſuch occaſions the tenderneſs of the dam is very extraordinary; leaving them in the deepeſt thicket, ſhe

offers

offers herſelf to the danger, flies before the hounds, and does all in her power to lead them from the retreat where ſhe has lodged her little ones. Such animals as are nearly upon her own level ſhe boldly encounters; attacks the ſtag, the wild cat, and even the wolf; and while ſhe has life, continues her efforts to protect her young.

Of all animals of the deer-kind, the rein-deer is the moſt uſeful. It is a native of the icy-regions of the north, and cannot live in a more ſouthern climate. Nature ſeems to have fitted it entirely for that hardy race of mankind that live near the pole. As theſe would find it impoſſible to ſubſiſt among their barren, ſnowy mountains, without its aid, ſo this animal can live only there. From it alone, the natives of Lapland and Greenland ſupply moſt of their wants. It anſwers the purpoſes of a horſe, to convey them and their ſcanty furniture, from one mountain to another; it anſwers the purpoſes of a cow, in giving milk; and of the ſheep, in furniſhing them with a warm, though a homely kind of clothing. From this alone, therefore, they receive as many advantages, as we derive from three of our moſt uſeful creatures. It is lower and ſtronger built than the ſtag; its legs are ſhorter and thicker, and its hoofs much broader; its hair is much thicker and warmer; its horns much larger in proportion, and branching forward over its eyes; its ears are much larger; its pace is rather a trot than a bounding, and this it can continue for a whole day; its hoofs are cloven and moveable, ſo that it ſpreads them abroad as it goes, to prevent its ſinking in the ſnow.

Lapland is divided into two diſtricts; the mountainous, and the woody. The mountainous part is barren and bleak, exceſſively cold, and uninhabitable, during the winter. Still, however, it is the moſt deſirable part of this frightful region, and is moſt thickly peopled, during the ſummer. The natives generally reſide on the declivity of the mountains, three or four cottages together. Upon the approach of winter, they migrate into the plains below, each bringing down his whole herd, which often amounts to more than a thouſand, and leading them where the paſture is in greateſt

plenty.

plenty. The woody part of the country is much more hideous: a frightful ſcene of trees without fruit, and plains without verdure. As far as the eye can reach, nothing is to be ſeen, even in the midſt of ſummer, but barren fields, covered only with moſs, no graſs, no flowery landſcapes, only here and there a pine tree, which may have eſcaped the frequent conflagrations, by which the natives burn down their foreſts. This moſs, however, which deforms the country, ſerves for its only ſupport, as upon it alone the rein-deer can ſubſiſt. The inhabitants, who, during the ſummer, lived among the mountains, drive down their herds in winter, and people the plains and woods below.

There is ſomething worthy our notice even in that deſpiſed animal, an aſs. There is a much greater reſemblance between the horſe and the aſs, than between the ſheep and the goat. And yet the latter produce an animal, that is not barren; whereas the mule always is.

The ſhe-aſs is not leſs fond of her young, than the male is of her. She will ruſh either through fire or water, to protect or rejoin it. An aſs is often no leſs attached to his owner. He ſcents him at a conſiderable diſtance; he diſtinguiſhes him from others, in a crowd. He knows the way wherein he has paſſed, and the places where he inhabits.

When over-loaded, he ſhews it by hanging down his head, and lowering his ears. If his eyes are covered, he will not ſtir a ſtep; and, if he is laid down in ſuch a manner that one eye is covered with the graſs, while the other is hidden with a ſtone, or whatever is next at hand, he will continue fixed in the ſame ſituation, and will not ſo much as attempt to riſe, to free himſelf from thoſe ſlight impediments. He walks, trots, and gallops, like a horſe, but is ſoon tired; and then no beating will mend his pace. It is in vain that his unmerciful rider exerts his whip or his cudgel: the poor, little animal bears it all with patience, and does not offer even to move.

The Spaniards, of all people in Europe, ſeem to be acquainted with the value of the aſs. They take all

all precautions to improve the breed, and a jack-aſs in Spain is above fifteen hands high. This animal, however, ſeems originally a native of Arabia. A warm climate is known to produce the largeſt and the beſt; their ſize and ſpirit decline, in proportion as they advance into colder regions.

In Guinea, they are larger and more beautiful, than even the horſes of the ſame country.

In Perſia, they have two kinds, one of which is uſed for burthens, being ſlow and heavy, the other is kept for the ſaddle, being ſmooth, ſtately, and nimble. An aſs will live above ſixty years. He ſleeps much leſs than the horſe; and never lies down for that purpoſe, unleſs very much tired. The ſhe-aſs goes above eleven months with young, and never brings forth more than one at a time.

The mule may be engendered, either between a horſe and a ſhe-aſs, or between a jack-aſs and a mare. The latter breed is every way preferable, being larger, ſtronger, and better ſhaped. The common mule is found very ſerviceable in carrying burthens, particularly in mountainous and ſtony places. Their manner of going down the precipices of the Alps is very extraordinary. In theſe paſſages, on one ſide, are ſteep eminences, and, on the other, frightful abyſſes; and, as they generally follow the direction of the mountain, the road, inſtead of lying in a level, forms at every little diſtance ſteep declivities, of ſeveral hundred yards downward. Theſe can only be defended by mules: and the animal itſelf ſeems ſenſible of the danger. When they come to the edge of one of theſe deſcents, they ſtop of themſelves, without being checked by the rider; and, if he inadvertently attempts to ſpur them on, they continue immoveable. They ſeem ruminating and preparing themſelves for the encounter. They not only attentively view the road, but tremble and ſnort. Having prepared for the deſcent, they place their fore-feet in a poſture, as if they were ſtopping themſelves; they then put their hinder feet together, but a little forward, as if they were going to lie down. In this attitude, having taken as it were a ſurvey of the road, they ſlide down

with

with the ſwiftneſs of the meteor. In the mean time, all the rider has to do is to keep himſelf faſt on the ſaddle, without checking the rein, for the leaſt motion is ſufficient to diſorder the mule; in which caſe they both unavoidably periſh. But their addreſs in this rapid deſcent, is truly wonderful; for in their ſwifteſt motion, when they ſeem to have loſt all government of themſelves, they follow exactly the different windings of the road, as if they had previouſly ſettled in their minds the route they were to follow.——In this journey, the natives, who are placed along the ſides of the mountains, and hold by the roots of the trees, animate the beaſt with ſhouts, and encourage him to perſeverance.

There are but three animals of the horſe-kind. The horſe, which is the moſt ſtately and courageous, the aſs, which is the moſt patient, and the zebra, which is the moſt beautiful, but at the ſame time the wildeſt animal in nature. Nothing can exceed the delicate regularity of this creature's colour, or the ſmoothneſs of its ſkin; but on the other hand, nothing can be more timid, or more untameable.

The zebra, or wild aſs, is chiefly a native of the ſouthern parts of Africa, and there are whole herds of them often ſeen feeding on the extenſive plains near the Cape of Good Hope. However, their watchfulneſs is ſuch, that they ſuffer nothing to come near them; and their ſwiftneſs ſo great, that they readily leave every purſuer far behind. The zebra, in ſhape, rather reſembles the mule than the aſs. Its ears are not ſo long as thoſe of the aſs, and yet not ſo ſmall as in the horſe-kind. Like the aſs, its head is large, its back ſtraight, and its tail tufted at the end; like the horſe, its ſkin is ſmooth and cloſe, and its hind quarters round and fleſhy. But its greateſt beauty lies in the amazing elegance of its colours. In the male, they are white and brown: in the female, white and black. Theſe colours are diſpoſed in alternate ſtripes over the whole body, and with ſuch exactneſs and ſymmetry, that one would think nature had employed the rule and compaſs to paint them. Theſe ſtripes, which, like

like ſo many ribbons are laid all over its body, are narrow, parallel, and exactly ſeparated from each other.

It is now not known, what were the pains and the dangers which were firſt undergone to reclaim the breed of horſes from ſavage ferocity: theſe, no doubt, made an equal oppoſition; but by being oppoſed by an induſtrious and enterpriſing race of mankind, their ſpirit was at laſt ſubdued, and their freedom reſtrained.

It is otherwiſe with regard to the zebra: it is the native of countries where the human inhabitants are but little raiſed above the quadruped. The natives of Angola or Cafraria, have no other idea of advantage from horſes, but as they are good for food; neither the fine ſtature of the Arabian courſer, nor the delicate colourings of the zebra, have any allurements to a race of people who only conſider the quantity of fleſh, and not its conformation. The delicacy of the zebra's ſhape, or the painted elegance of its form, are no more regarded by ſuch, than by the lion that makes it his prey. Perhaps the zebra may have hitherto continued wild, becauſe it is the native of a country where there have been no efforts made to reclaim it. All purſuits then were rather againſt its life than its liberty; the animal has thus been long taught to conſider man as its mortal enemy; and it is not to be wondered, that it refuſes to yield obedience where it has ſo ſeldom experienced mercy.

All animals ſeem perfectly to know their enemies, and to avoid them at the ſame time; which we cannot account for. Inſtinct, indeed, may teach the deer to fly from the lion; or the mouſe to avoid the cat:—but what is the principle that teaches the dog to attack the dog-butcher wherever he ſees him? In China, where the killing and dreſſing dogs is a trade, whenever one of theſe move out, all the dogs in the village, or the ſtreet, are ſure to be after him.

I have ſeen, (ſays Dr. G—) more than one inſtance of the ſame kind among ourſelves. I have ſeen a poor fellow, who made a practice of ſtealing and killing dogs for their ſkins, purſued hue and cry for three or four ſtreets together, by all the bolder breed of dogs, while the weaker flew from his preſence with affright.

How

How theſe animals could thus find out their enemy, and purſue him, is unaccountable; but ſuch is the fact; and it not only obtains in dogs, but in ſeveral other animals, though perhaps to a leſs degree.

The noiſe of the zebra is neither like that of a horſe or aſs, but more reſembling the confuſed barking of a maſtiff dog. In the two which I ſaw, there was a circumſtance, that ſeems to have eſcaped naturaliſts; which is, that the ſkin hangs looſe below the jaw, upon the neck, in a kind of dewlap, which takes away much from the general beauty.

The ſquirrel is a beautiful little animal; which from the gentleneſs of its manners, deſerves our protection. It is not hurtful, its uſual food is fruits, nuts and acorns; it is cleanly, nimble, active, and induſtrious; its eyes are ſparkling, and its phyſiognomy marked with meaning. It generally, like the hare and rabbit, ſits upon its hinder legs, and uſes the fore paws as hands; theſe have five claws as they are called, and one of them is ſeparated from the reſt like a thumb. This animal ſeems to approach the nature of a bird, from its lightneſs and ſurpriſing agility. It ſeldom deſcends to the ground, except in caſe of ſtorms, but jumps from one branch to another; feeds in ſpring, on the buds and young ſhoots; in ſummer, on the ripening fruits: and particularly the young coves of the pine tree. In autumn it has an extenſive variety, the acorn, the filbird, the cheſnut, and the wilding. This ſeaſon of plenty, however, is not ſpent in idle enjoyment; the provident little animal gathers at that time its proviſions for the winter, and cautiouſly foreſees the ſeaſon when the foreſt ſhall be ſtripped of its leaves and fruitage.

Its neſt is generally formed among the large branches of a great tree, where they begin to fork off into ſmall ones. After chuſing the place where the timber begins to decay, and a hollow may eaſily be formed, the ſquirrel begins by making a kind of level between the forks; and then bringing moſs, twigs, and dry leaves, it binds them together with great art, ſo as to reſiſt the moſt violent ſtorm. This is covered on all ſides; and has but a ſingle opening at top, which is juſt large

enough to admit the little animal; and this opening is itſelf defended from the weather by a kind of canopy that throws off the rain, though never ſo heavy. The neſt thus formed, with a very little opening above, is, nevertheleſs, very commodious and roomy below; ſoft, well knit together, and every way convenient and warm. In this retreat the little animal brings forth its young, ſhelters itſelf from the heat of the ſun, which it ſeems to fear, and from the ſtorms and inclemency of the winter, which it is ſtill leſs capable of ſupporting. Its proviſion of nuts and acorns is ſeldom in its neſt, but in the hollows of the tree, laid up carefully together, and never touched but in caſes of neceſſity. Thus one ſingle tree ſerves for a retreat and a ſtore-houſe, and without leaving it during the winter, the ſquirrel poſſeſſes all thoſe enjoyments that its nature is capable of receiving.

The marmot is almoſt as big as a hare, but is more corpulent than a cat, and has ſhorter legs. Its head pretty nearly reſembles that of a hare, except that its ears are much ſhorter. It is clothed all over with very long hair, and a ſhorter fur below. Theſe are of different colours, black and grey.

The length of the hair gives the body the appearance of greater corpulence than it really has, and at the ſame time ſhortens the feet ſo that its belly ſeems to touch the ground. Its tail is tufted and well furniſhed with hair, and it is carried in a ſtrait direction with its body. It has five claws behind, and only four before. Theſe it uſes as the ſquirrel does, to carry its food to its mouth, and it uſually ſits upon its hinder parts to feed in the manner of that little animal. It is readily taught to dance, to wield a cudgel, and to obey the voice of its maſter. Like the cat, it has an antipathy to the dog, and when it becomes familiar to the family, and is ſure of being ſupported by its maſter, it attacks and bites even the largeſt maſtiff. From its ſquat muſcular make, it has great ſtrength joined to great agility. However, it is in general a very inoffenſive animal: and, except its enmity to dogs, ſeems to live in friendſhip with every creature, unleſs when provoked. As its legs are very ſhort, and made ſomewhat like

thoſe

thoſe of a bear, it is often ſeen ſitting up, and even walking on its hind legs. Like all the hare kind, it runs much ſwifter up hill than down; it climbs trees with great eaſe, and runs up the clefts of rocks, or the contiguous walls of houſes, with great facility.

Thoſe arms which the hedge-hog poſſeſſes in miniature, the porcupine has in an enlarged degree.

In the one, the ſpines are but an inch long; in the other, a foot. The porcupine is about two feet long, and fifteen inches high. It is covered with quills from ten to fourteen inches long, reſembling the barrel of a gooſe-quill in thickneſs; but tapering and ſharp at both ends. Each quill is thickeſt in the middle; and inſerted into the animal's ſkin, in the ſame manner as feathers in birds. The biggeſt are often fifteen inches long, and a quarter of an inch in diameter; extremely ſharp, and capable of inflicting a mortal wound.—They are harder than common quills, and ſolid at the end which is not fixed in the ſkin. All theſe quills, incline backwards, like the briſtles of a hog; but when the animal is irritated, riſe, and ſtand upright.

Such is the formation of this quadruped, in thoſe parts in which it differs from moſt others. As to the reſt of its figure, the muzzle bears ſome reſemblance to that of a hare, but black; the legs are very ſhort, and the feet have five toes, both before and behind; and theſe, as well as the belly, the head, and all other parts of the body, are covered with a ſort of ſhort hair, like prickles; there being no part, except the ears and the ſole of the foot, that is free from them: the ears are thinly covered with very fine hair; and are in ſhape like thoſe of mankind: the eyes are ſmall like thoſe of a hog, being only one third of an inch from one corner to the other. After the ſkin is taken off, there appears a kind of paps on thoſe parts of the body from whence the large quills proceed; theſe are about the ſize of a ſmall pea, each anſwering to as many holes as appear on the outward ſurface of the ſkin, and which are about half an inch deep, like as many hollow pipes, wherein the quills are fixed, as in ſo many ſheaths.

This animal partakes much of the nature of the hedge-hog; having this formidable apparatus rather to defend itſelf, than annoy the enemy. Indeed many have ſuppoſed that it was capable of diſcharging at its foes, its quills. But, it is now well known that its quills remain fixed in the ſkin, and are then only ſhed, when the animal moults them, as birds do their feathers.

The pangolin, a native of the torrid climates of the ancient continent, is, of all animals, the beſt protected from external injury. It is three or four feet long, or, taking in the tail, from ſix to eight. It has a ſmall head, a very long noſe, a ſhort thick neck, a long body, legs very ſhort, and a tail extremely long. It has no teeth, but is armed with five toes on each foot, with long white claws. But what it is chiefly diſtinguiſhed by, is its ſcaly covering. Theſe ſcales defend the animal on all parts, except the under part of the head and neck, under the ſhoulders, the breaſt, the belly, and the inner ſide of the legs; all which parts are covered with a ſmooth, ſoft ſkin, without hair. The ſcales of this extraordinary creature are of different ſizes and different forms, and ſtuck upon the body ſomewhat like the leaves of an artichoke. The largeſt are near the tail, which is covered with them like the reſt of the body. Theſe are above three inches broad, and about two inches long; thick in the middle, and ſharp at the edges. They are extremely hard, like horn. They are convex on the outſide, and a little concave on the inner; one edge ſticks in the ſkin, while the other laps over that immediately behind it. Thoſe that cover the tail are ſo hard, when the animal has acquired its full growth, as to turn a muſquet-ball.

This lapped round the reſt of the body, and, being defended with ſhells even more cutting than any other part, the creature continues in perfect ſecurity. Its ſhells are ſo large, ſo thick, and ſo pointed, that they repel every animal of prey; they make a coat of armour that wounds while it reſiſts, and at once protects and threatens. The moſt cruel beaſts of the foreſt, the tiger, the panther, and hyæna, make vain attempts

tempts to force it. They roll it about, but all to no purpose; the pangolin remains safe while its invader feels the reward of its rashness.

The armadillo is chiefly an inhabitant of South America; a harmless creature, incapable of offending any other, and furnished with a peculiar covering for its own defence.

This animal being covered like a tortoise, with a shell, or rather a number of shells, its other proportions are not easily discerned. It appears at first view, a round misshapen mass, with a long head, and a very large tail sticking out at either end.

It is of different sizes, from a foot to three feet long, and covered with a shell, divided into several pieces, that lap over each other, like the plates in the tail of a lobster. This covers the head, the neck, the back, the sides, the rump, and the tail, to the very point. The only parts to which it does not extend are, the throat, the breast, and the belly, which are covered with a white soft skin. By this means the animal has a motion in its back, and the armour gives way to its necessary inflexions. These shells are differently coloured in different kinds, but most usually they are of a dirty grey. This colour in all arises from another peculiar circumstance in their conformation; for the shell itself is covered with a softish skin, which is smooth and transparent.

Beasts may be considered as a numerous groupe, terminated on every side by some, that but in part deserve the name. On one quarter we see a tribe covered with quills, or furnished with wings, that lift them among the inhabitants of the air; on another, we behold a diversity clothed with scales and shells, to rank with insects; and still, on a third, we see them descending into the waters, to live among the mute tenants of that element. We now come to a numerous tribe, that seem to make approaches even to humanity; that bear an aukward resemblance of the human form, and discover the same faint efforts at intellectual sagacity.

Animals of the Monkey claſs are furniſhed with hands inſtead of paws; their ears, eyes, eye-lids, lips, and breaſts, are like thoſe of mankind; their internal conformation alſo bears ſome diſtant likeneſs; and the whole offers a picture that may mortify the pride of ſuch as make their perſons the principal object of their admiration.

Theſe approaches, however, are gradual, and ſome bear the marks of our form, more ſtrongly than others.

In the ape-kind, we ſee the whole external machine ſtrongly impreſſed with the human likeneſs; theſe walk upright, want a tail, have fleſhy poſteriors, have calves to their legs, and feet nearly like ours.

In the baboon-kind, we perceive a more diſtant approach; the beaſt mixing in every part of the animal's figure: theſe generally go upon all fours; but ſome, when upright, are as tall as a man: they have ſhort tails, long ſnouts, and are poſſeſſed of brutal fierceneſs.

The Monkey-kind are removed a ſtep further: theſe are much leſs; with tails as long as their bodies, and flattiſh faces.

Laſtly, the opoſſum-kind, ſeem to loſe all reſemblance of the human figure, except in having hands, their noſes are lengthened out, and every part of their bodies totally different from the human; however, as they graſp their food, with one hand, which beaſts cannot do, this ſingle ſimilitude gives them an air of ſagacity, to which they have ſcarce any other pretenſions.

The baboon, is from three to four feet high, very ſtrong built, with a thick body and limbs, and canine teeth, much longer than thoſe of men. It walks more commonly upon all fours than upright, and its hands as well as its feet are armed with long, ſharp claws, inſtead of the broad, round nails of the ape-kind.

At the Cape of Good-Hope, they are under a ſort of natural diſcipline, and go about whatever they undertake

dertake with ſurpriſing ſkill and regularity. When they ſet about robbing an orchard or vineyard, (for they are extremely fond of grapes, and apples) they go in large companies, and with preconcerted deliberation; part of them enter the encloſure, while one is ſet to watch. The reſt ſtand without the fence, and form a line reaching all the way from their fellows within to their rendezvous without, which is generally in ſome craggy mountain. Every thing being thus diſpoſed, the plunderers within the orchard throw the fruit to thoſe that are without as faſt as they can gather it; or, if the wall or hedge be high, to thoſe that ſit on the top; and theſe hand the plunder to thoſe next them on the other ſide. Thus the fruit is pitched from one to another all along the line, till it is ſafely depoſited at their head quarters. They catch it as readily as the moſt ſkilful tennis-player can a ball; and while the buſineſs is going forward, a profound ſilence is obſerved. Their ſentinel, during this whole time, continues upon the watch, and if he perceives any one coming, inſtantly ſets up a loud cry, on which ſignal, the whole company ſcamper off.—Nor yet are they willing to go empty handed; for if they be plundering a bed of melons, for inſtance, they go off with one in their mouths, one in their hands, and one under their arm. If the purſuit is hot, they drop firſt that from under their arm, then that from their hand; and, if it be continued, they at laſt let fall that which they had kept in their mouths.

The chimpanaze is an animal found in Angola, nearly approaching to the human figure; but of a fierce diſpoſition, and remarkably miſchievous. In the year 1738, one of theſe creatures was brought over to England. It was about twenty months old [The parent had it in her arms, when ſhe was killed: ſhe was five feet high.]. It was of the female ſex, naturally walked erect, was hairy on ſome part of the body and limbs, and of a ſtrong, muſcular make. It would eat any courſe food, but was very fond of tea, which it drank out of a cup, with milk and ſugar, as we do. It ſlept in the manner of the human ſpecies, and its voice reſembled the human, when people ſpeak very

very haſtily; but without any articulate ſounds. The males of this ſpecies are very bold, and will fight a man, though he is armed. It is ſaid, they often aſſault and raviſh the negro women, when they meet them in the woods.

There is another ſtrange ſpecies of monkey found in the Weſt-Indies, of the ſize of a fox. Its face is raiſed high, its eyes black and ſhining, and its ears ſmall and round. His hairs are ſo nicely diſpoſed all over the body, that he appears perfectly ſmooth: and they are much longer under the chin, ſo that they form a kind of beard there.

Theſe are found in great numbers in the woods, and make a loud and frightful noiſe. But it is very common for one only to make a noiſe, and the reſt to form a mute aſſemby round him.

Marcgrave ſays, "I have frequently ſeen great numbers of them, meeting about noon: at which time they formed a large circle, and one placing himſelf above the reſt, began to make a loud noiſe.—When he had ſung thus by himſelf, for ſome time, the reſt all remaining ſilent, he lifted up his hand, and they all inſtantly joined in a ſort of chorus. This intolerable yell continued, till the ſame monkey, who gave the ſignal for their beginning, lifted up his hand a ſecond time. On this they were all ſilent again, and ſo finiſhed the buſineſs of the aſſembly."

The opoſſum, is about the ſize of a cat, only more corpulent, and its legs more robuſt. It is of a kind of cheſnut colour, very bright and gloſſy. Its head is long, and terminates in a ſnout, ſomewhat like a fox's. The tail is long, and much reſembles that of a rat, which it twiſts about with a ſurpriſing facility. The legs being ſhort, the body is carried at no great diſtance from the ground. On the belly of the female, a bag is formed by the ſkin being doubled. It is not very deep, the cloſeſt part being toward the upper part of the body, and the open part toward the lower.—This is covered with fur, like the reſt of the body, ſo that it is not very obvious to the ſight.

It

It is a harmleſs, but likewiſe a defenceleſs animal: and the young of no creature, are produced ſo ſmall and tender, in reſpect of the parent animal. Therefore that bag is extremely uſeful to them. They are cheriſhed there by the warmth of the parent's body, till toward noon: then they go abroad, till at the firſt warning by the evening-cold, they retire into their lodging again. Nor is this all the help which it affords. For as the tender young of the opoſſum are delicate morſels, they would be expoſed to the rage of many animals, both by day and night. But the body of the parent is a ſafe and ready receptacle for them. By day ſhe is as watchful over her brood, as a hen over her chickens. She is alarmed at the ſlighteſt appearance of danger, and by a noiſe which they well underſtand, inſtantly calls them into her bag. At night ſhe conſtantly takes them in, and conſults for herſelf and them in a very uncommon manner. There are thoſe among the devourers of her young, who will climb a tree after her. Therefore when ſhe has climbed, to ſecure herſelf and her young ſtill farther, ſhe twiſts her tail twice round ſome ſmall bough, and then drops from it. There ſhe hangs with her head downward: and whenever ſhe pleaſes, ſhe recovers the branch with her feet by a ſwing, and looſening her tail, walks about as uſual.

To enable her thus to hang, there are ſpikes or hooks in the under ſide of the vertebræ of the tail. Indeed, in the firſt three vertebræ there are none; for there they would be of no uſe. But they are found in all the reſt. They are placed juſt at the articulation of each joint, and in the middle from the ſides. Nothing could be more advantageouſly contrived. For when the tail is twiſted round a bough, theſe hooks eaſily ſuſtain the weight. And there is no more labour of the muſcles required, than juſt to bow or crook the tail.

Another animal of a very peculiar kind is an Ichneumon. It is of the weaſel-kind, with a longer and narrower body than a cat, ſomething approaching to the ſhape and colour of a badger. Its noſe is black and ſharp, like that of a ferret. Its colour is a yellowiſh grey. Its legs are ſhort, and each of its feet

has five toes. Its tail is very long; its teeth and tongue much like thoſe of a cat. It is a very cleanly animal, very briſk and nimble, and of great courage. It will engage a dog, and will deſtroy a cat, by three bites on the throat. But it is quite inoffenſive to mankind, and is kept tame in Egypt, running about the houſe, deſtroying all vermin, and playing tricks, like ſpaniels.

When wild, he cannot overtake any nimble animal. But he makes this up by aſſiduity. His legs being ſhort, he is not much ſeen: but he has a way of concealing himſelf yet more, by crawling with his belly cloſe to ground, which he does all day long. But on the leaſt noiſe (for his hearing is exceeding quick) he ſtarts up erect on his hinder legs. If the noiſe is made by any reptile, bird, or ſmall beaſt, he obſerves where abouts it is, places his noſe directly in a line with it, and begins to move toward it. He is ſilent and ſlow, but conſtant in his approach; often ſtopping to hear or look forward, and knows exactly where the creature is: when he is got within about five feet, he ſtops. Nature, which has denied him ſpeed, has given him ſtrength to leap, beyond moſt other creatures. Having taken good aim, he ſprings from the place, and falls directly on his prey. Thus he deals with beaſts and birds. But to ſerpents he gives chace, and to avoid their bite, always ſeizes them by the neck.

Geſner tells, that the Ichneumon is not only an enemy to ſerpents themſelves, but to their eggs alſo: which he hunts after continually and deſtroys, though he does not feed upon them.—How mercifully has God given this animal in the countries where thoſe terrible reptiles moſt abound! And which, without this proviſion, would be ſo over-run with them, as to be uninhabitable.

The jackal is of the carnivorous kind. They hunt by ſcent and go in packs. They purſue with patience, rather than ſwiftneſs, and excite each other by a ſpirit of emulation.

It goes for current that the jackal diſcovers the lion's prey; that each of theſe retains one of them,

and

and having ſatisfied himſelf, lets his dependent feed on the offals of his repaſt.

But the truth is, there are great numbers of jackals in ſome woods, and when one of theſe ſees a ſtag, or other large beaſt, which is not a beaſt of prey, he ſets up his cry, which is like that of a hound, and follows it. As he continues his cry, the other jackals that are within hearing follow likewiſe. And could the creature out-run thoſe that began the chace, there is a continual ſupply; ſo that it cannot eſcape. When they have run it down, they worry it at once, and it is devoured almoſt in an inſtant. After this the jackals diſperſe, till another cry invites them.

They hunt generally in the night, and in the parts of the Eaſt, where they are moſt frequent, there never is a night but they are heard, in one part or other of the woods. The other beaſts of prey underſtand the ſound: and frequently profit by it. If a lion, tyger, or leopard happens to be near, he hears the cry, and ſtands upon the watch. Theſe large animals are all very ſwift, but they are lazy, and never make long purſuits. If the creature purſued be far off, and runs another way, they never trouble themſelves about it. But if it be near, or if it run toward the place where the lion is, he will dart out upon it as it goes by. And the little animals that hunted it down muſt ſtand by, and be content with what their maſter leaves.

The ſable-mice, (which were firſt obſerved in Lapland, in 1697) are near as big as a ſmall ſquirrel.—Their ſkin is ſtreaked and ſpotted with black and light brown. They have two teeth above, and two under, very ſharp and pointed. Their feet are like a ſquirrel's. They are ſo fierce, that if a ſtick be held out to them, they will bite it, and hold ſo faſt, that they may be ſwinged about in the air. In their march they keep a direct line, generally from north-eaſt to ſouth-weſt. Innumerable thouſands are in each troop, which is uſually a ſquare. They lie ſtill by day, and march by night. The diſtance of the lines they go in, parallel to each other, is of ſome ells. Whatever they meet in their way, though it were a fire, a deep well, a torrent, lake, or moraſs, they avoid it not, but ruſh forward. By this means many thouſands of them are deſtroyed.

deſtroyed. If they are met ſwimming over a lake and are forced out of their courſe, they quickly return into it again. If they are met in woods or fields and ſtopt, they raiſe themſelves on their hinder legs, like a dog, and make a kind of barking noiſe, leaping up as high as a man's knee, and defending their line as long as they can. If at laſt they are forced out of it, they creep into holes, and ſet up a cry, ſounding like biab, biab. If a houſe ſtands in their way, they never come into it, but ſtop there till they die. But they will eat their way through a ſtack of corn or hay.—When they march through a meadow, they eat the roots of the graſs: and if they encamp there by day, they utterly ſpoil it, and make it look juſt as if it had been burnt. They are exceeding fruitful; but their breeding does not hinder their march. For ſome of them have been obſerved, to carry one young in their mouth, and another upon their back. In winter they live under the ſnow, having their breathing-holes, as hares and other creatures have.

I would mention only two creatures more, very extraordinary, and yet but little known.

The glutton is frequent in the foreſts of Germany. It is rarely ſeen twice of the ſame figure. It is of the weaſel-kind, and is in its middle ſtate, about the ſize of a turn-ſpit dog. Its body is long, its legs ſhort.—Its colour is brown, with a reddiſh tinge; but its breaſt and belly are white. The tail is long and buſhy; the head ſmall and ſharp at the noſe. The teeth are exceeding ſharp, and the claws ſharper than almoſt in any creature.

This is the moſt hungry animal in the world, but is ill provided for catching its prey. Moſt creatures can out-run it, and itſelf can ſcarce run away from any thing. But what he wants in ſwiftneſs, he has in climbing, which he performs to admiration: its ſharp claws enabling it to run up a tree as faſt as on the ground. Its uſual place is ſome large and ſpreading oak, choſe both for ſafety and for catching its prey. He ſquats all day on ſome large branch; and if nothing offers below, he preys in the night on whatever creatures he can find on the tree above. Many birds rooſt on ſuch trees,

trees, which he climbs ſoftly to, and devours. But his favourite food is larger animals. He will lie many days on a ſlanting bough; and when any which he likes comes underneath, he drops down upon them.—Hares and rabbits ſeldom eſcape him; but he chuſes rather a goat, or any creature of that ſize. When one of theſe come under the tree, he creeps from bough to bough, till he comes juſt over it, and then drops down upon it. He always contrives to faſten on the neck. In an inſtant, he fixes both his teeth and claws, and lies acroſs the neck, near the ſhoulders. Here he is ſecure; and while the poor creature runs with all its ſpeed, he is feeding on its fleſh. At length it drops, and he continues eating in the ſame ravenous manner, till from a mere ſkeleton, his back becomes round, and his ſides ſwelled out like a tun. Still he continues to eat, till he can eat no longer. He too drops down, and lies panting for breath. He reſembles a dead carcaſe, ſwelled and ready to burſt with lying in the ſun: and being unable to move for a long time, is frequently deſtroyed, and ſometimes periſhes without an enemy.

The God of Nature ſeems to have formed the ſloth, to repreſent to us in a ſtrong light, that odious and deſpicable vice, from which it takes its name. Its body is ſhort, its head ſmall, and it has ſcarce any tail.—Its fur is long, thick, and of a greyiſh green, ſo that when ſeen on the bough of a tree, it appears only like an excreſcence or a cluſter of moſs. It is about the ſize of cat, but the legs are ſhort, as is the neck: and its long and thick covering, renders it ſo ſhapeleſs, that it ſeems only an irregular lump of living matter. Its little and remarkably ugly head ſtands cloſe between the ſhoulders. The face has much of the monkey aſpect. Its ſmall and heavy eyes, are always half ſhut, and it has no appearance at all of any ears. Its feet are flat and very narrow, but armed with ſharp claws, for laying hold on the bark of a tree, by ſtriking deep into it.

He rarely changes his place; and never, but when compelled by abſolute neceſſity. As upon the ground it would be a prey to every other animal, ſo its conſtant reſidence is on a tree. Here it is ſafe from all animals, but

but thoſe who climb theſe trees for the birds that rooſt on them. The leaves and tender part of the tree are its food, and ſerve it for drink as well as meat. It never moves to another branch, till it has devoured all the nouriſhment upon that where it is ſtationed: nor from one tree to another, till the firſt is wholly withered and waſted.

It is obſervable, the ſloth always aſcends to the top of a tree, only baiting as he goes, before he begins his devaſtations. And this is doubtleſs from the inſtinctive guidance of nature. For was it to begin eating upward, when it had devoured all, it would have to climb down from the top of a dead tree, and would be half ſtarved in its journey. But this is not all.—The havoc which one ſloth makes on the largeſt tree is eaſily ſeen. For he eats not only the leaves, but all the buds and bark, leaving only a dead branch: ſo that unleſs the ſame thing might happen by accident, this would betray the creature. It does ſo happen; and trees then put on the ſame form, as when they are left by the ſloth. But they always die at the top firſt, and ſo gradually downward. This animal therefore, wonderfully taught, begins its havoc at the top. As it feeds, the tree decays; but its decay is in the courſe of nature. The decay ſpreads downward; and when he has eaten the laſt of his proviſion, he is near the ground, and has only to walk away to another tree. But if it is at any diſtance, his motion is ſo ſlow, that he grows quite lean in the expedition.

As the ſloth brings forth her young in the hollow of a tree, ſo is ſhe led by the ſame wonderful inſtinct, to conduct them to the topmoſt branches, as ſoon as they crawl out. When ſhe is big with young, ſhe climbs ſome old, hollow tree; and having fixed on a convenient ſpot for her young, ſhe climbs to the very higheſt bough, and there feeds faſter than uſual. When ſhe is full, ſhe deſcends with unaccuſtomed haſte, and brings forth one, two, or three young ones. It is well ſhe is full fed; for ſhe is to ſupport theſe with her milk, till they can crawl out, without having any ſupply herſelf. She is round and fleſhy when ſhe retires for this purpoſe, but a mere ſkeleton when ſhe comes out. She crawls as well as ſhe can, to the part where ſhe left

left off feeding, and her young follow her. Nor will she touch any thing in the way, however both her hunger and her laziness may prompt her to it.

It is the most timorous of all creatures. And with reason; for it can neither fight nor fly. While it is journeying on the ground, the tread of a human foot shakes the earth enough to put it into terrors. It trembles: the head is turned about every way, and the mouth is open to cry like a young kitten.

Insignificant as this creature is, there is a special Providence in the formation and care of it. Not designed for walking, its claws enable it to climb, and then to hold fast its station. Helpless as it is, the universal Provider has assigned it a place of safety, where it finds plenty of food; and as it cannot easily seek for drink, it has no need of any. To render it the less obnoxious to pursuit, its colour secures it even from view: and its amazing instinct of feeding from the top to the bottom, proves a designing and directing hand.

Before I proceed to some general reflections upon beasts, I beg leave to take notice of one circumstance, relating to several species of them, which is very strange, though very common.—The horns of many animals fall off every year, and new ones come in their place. Our deer drop them in March, and the new horns are full grown by the July following. We may very justly rank this, among the most wonderful phenomena of nature, which yields nothing analogous to the growth of such hard solid bodies, of so great a bulk, in so short a time. Many idle opinions have been maintained, concerning the cause of their falling off. The truth seems to be this: they are a sort of vegetables, growing on animals, as the nails and hair on man, and feathers on birds. And there is some analogy between the growth of them, and that of branches and leaves on trees. Trees commonly drop their leaves in Autumn, because the nourishing juice flows into them no longer. And at certain periods, these parts of the animal drop off, because the blood and juices cease to flow in them. At this time, the hollow part at the root of the horn grows hard, and the pores through which

which the juices paſſed, grows up. And as no more nouriſhment can then be carried to the horn, it decays and falls off. It is probable this ſtoppage of the pores happens, as ſoon as the horns are at their full growth. But they are ſo fixt to the head, that it takes a long time for them to looſen and fall. Whereas in leaves, their ſtalks are ſo tender, that when the juice ceaſes to flow, they preſently wither and fall.

The analogy between the falling off of deers horns and the falling of leaves and ripe fruit from the tree, will receive light from obſerving the proceſs of nature in the latter caſe. If the ſtalk from which a ripe orange has fallen, be compared with that part of a deer's forehead, from which a horn is juſt fallen, it will plainly appear, that nature has operated by the ſame laws in both. The young horns, while yet ſoft, are full of blood-veſſels; and if cut off, eſpecially near the head, bleed violently. By theſe veſſels they are ſupplied with nouriſhment for their growth. But theſe dry up, when there is no farther occaſion for them. And hence it is, that no ill ſymptoms attend the falling off of theſe parts, when full grown.

So far we may give a probable account:—But who can account for this, that if a ſtag be caſtrated, while he is ſo young as not to have horns, he will never have any: and if caſtrated afterward, while his horns are on, he will never caſt them?

10. It remains only to add a few reflections. And firſt, What admirable wiſdom is diſplayed, in the motion of various animals, ſuited to their various occaſions! In ſome, their motion is ſwift; in others, ſlow; and both diverſified a thouſand ways.

And firſt, for ſwift or ſlow motion. This is exactly proportioned to the occaſion of each animal. Reptiles, whoſe food, habitation, and neſts lie in the next clod, plant, tree, or hole, or which can bear long hunger, need neither legs, nor wings, but their vermicular motion anſwers all their purpoſes.

Beaſts, whoſe occaſions require a larger room, have accordingly a ſwifter motion: and this in various degrees, anſwerable to their range for food, and the enemies they are to eſcape from.

But

But as for birds, who are to traverſe vaſt tracts of land and water; for their food, habitation, breeding their young, and for places of retreat and ſecurity, from various inconveniences: they are endowed with the faculty of flying; and that ſwiftly or ſlowly, a long or ſhort time, according to their occaſions. In all this, the wiſdom of God appears, ordering all things well.

Again. How admirable in the motion of all creatures, is the neat, geometrical performance of it!—The moſt accurate mathematician cannot preſcribe a nicer motion than that they perform, to the legs and wings of thoſe that fly or walk, or to the bodies of thoſe that creep. Neither can the body be more completely poiſed, for the motion it is to have in every creature. From the largeſt elephant to the ſmalleſt mite, the body is exactly balanced. The head is not too heavy, nor too light for the reſt of the body, nor the reſt of the body for it. The bowels are not looſe, or ſo placed as to ſwag, overbalance, or overſet the body: but well braced, and accurately diſtributed to maintain the equipoiſe of it. The motive parts alſo are admirably well fixed, in reſpect to the centre of gravity, placed in the very point which beſt ſerves to ſupport and convey the body. Every leg bears its true ſhare of the weight. And the wings are ſo exactly placed, that even in the fluid medium, the air, the body is as truly balanced, as we could have balanced it with the niceſt ſcales.

Yet again. What an admirable proviſion is made for the motion of ſome creatures, by temporary parts! Frogs, for inſtance, have tails in their tadpole ſtate, which fall off when their legs are grown out. The water-newt alſo, when young, has four fins, two on a ſide, to poiſe and keep the body upright. But as ſoon as the legs are fully grown, theſe preſently drop off.

Secondly, The bore of the gullet in all creatures, is anſwerable to their occaſions. In a fox, which feeds on bones, (as in all offivorous beaſts) it is very large. But in a ſquirrel it is exceeding ſmall, leſt he ſhould diſgorge his meat in his deſcending leaps: and ſo in rats and mice, which often run along a wall with their heads downward.

Thirdly,

Thirdly, In all animals the ſtrength and ſize of their ſtomach are proportioned to their food. Thoſe whoſe food is more tender and nutritive, have it ſmaller, thinner, and weaker. Whereas it is large and ſtrong in thoſe whoſe food is leſs nutritive, and whoſe bodies require large ſupplies.

All carnivorous beaſts have the ſmalleſt ſtomachs, as fleſh goes the fartheſt. Thoſe that feed on fruits and roots have them of a middle ſize. Sheep and oxen, which feed on graſs, have the greateſt. Yet the horſe, hare, and rabbit, though granivorous, have comparatively ſmall ones. For a horſe is made for labour, and both this and the hare for quick and continued motion: for which the moſt eaſy reſpiration, and ſo the freeſt motion of the diaphragm is requiſite.—But this could not be, did the ſtomach lie big and cumberſome upon it, as it does in ſheep and oxen.

Another very remarkable circumſtance is, that thoſe animals which have teeth on both jaws, have but one ſtomach; whereas moſt of thoſe which have no upper-teeth, or no teeth at all, have three ſtomachs. For the meat which is firſt chewed, is eaſily digeſted; but that which is ſwallowed whole, requires a ſtronger concoctive power.

Fourthly, All the parts of the ſame animal are adapted one to the other. So, for inſtance, the length of the neck is always proportioned to that of the legs. Only the elephant has a ſhort neck: for the weight of his head and teeth, would to a long neck, have been inſupportable. But then he is provided with a trunk, which abundantly ſupplies the defect. In other beaſts and birds, the neck is always commenſurate to the legs: ſo that they which have long legs, have long necks, and they that have ſhort legs, ſhort necks; as may be obſerved in lizards of all kinds, and the king of them, the crocodile. And creatures that have no legs, as they want no necks, ſo they have none, as fiſhes. This equality between the length of the neck and legs, is peculiarly ſeen in beaſts that feed on graſs. Their legs and necks are very near equal. Very near, I ſay, becauſe the neck muſt neceſſarily have ſome advantage;

tage; for it cannot hang perpendicular, but muſt incline a little.

Moreover, as theſe creatures muſt hold their heads down, for a conſiderable time together, which would be very laborious and painful for the muſcles, therefore on each ſide of the neck, nature has placed a thick and ſtrong ligament, capable of ſtretching and ſhrinking again as need requires: this, which is vulgarly called white-leather, extends from the head (to which, and the next vertebræ of the neek it is faſtened at that end) to the middle vertebræ of the back, to which, it is knit at the other. And by the aſſiſtance of this, they are able to hold the head in that poſture all the day long.

Fifthly, The parts of all animals are exactly fitted to their manner of living. A notable inſtance of this is in the ſwine. His natural food being chiefly the roots of plants, he is provided with a long and ſtrong ſnout; long, that he may thurſt it to a convenient depth in the ground, without offence to his eyes; ſtrong and conveniently formed, for rooting and turning up the ground. And beſides, he has an extremely quick ſcent, for finding out ſuch roots as are fit for him. Hence in Italy, the uſual way of finding truffles, or ſubterraneous muſhrooms, is by tying a cord to the hind-leg of a pig, and driving him before them into their paſtures. They then obſerve, where he ſtops and begins to root: and digging there they are ſure to find a truffle. So in paſtures where there are earth-nuts, though the roots are deep in the ground, and the leaves are quite gone, the ſwine will find them by their ſcent, and root only in the places where they grow.

Another inſtance of like nature we have in the porpus anciently wrote porc-peſce, that is, ſwine-fiſh) which reſembles the hog, both in the ſtrength of his ſnout and in the manner of getting his food. For the ſtomach of one of theſe when diſſected, was found full of ſand eels, which lie deep in the ſand, and cannot be gotten, but by rooting and digging there.

That very action, for which we look upon ſwine as unclean creatures, namely, wallowing in the mire, is

deſigned

deſigned by nature for a good end; not only to cool their bodies (which fair water would do as well) but alſo to ſuffocate and deſtroy fleas, lice, and other inſects, which are troubleſome and hurtful to them. For the ſame reaſon, poultry and divers other birds baſk themſelves in the duſt, in hot ſummer weather.

The variety of ſhape and colour obſervable in beaſts, prevents any two from being exactly alike, as much as the human features diſtinguiſh mankind one from another. Wherefore then was this variety beſtowed upon brutes? Are they at all ſenſible of ſuch diverſity? Are they the more happy, or more uſeful to one another for it? No. This variety then is doubtleſs intended for the ſake of man, to prevent confuſion, and decide and aſcertain his property.

CHAP. II.

Of BIRDS.

1. *Some general Remarks:*
2. *Of their Motion:*
3. *Brain:*
4. *Organs of Senſe:*
5. *Lungs:*
6. *Stomach and Bladder.*
7. *Generation.*
8. *Of ſome particular Sorts of Birds.*
9. *Reflections.*

I. NO part of nature is deſtitute of inhabitants. The woods, the waters, the depths of the earth, have their reſpective tenants; while the yielding air, and thoſe tracts where man never can aſcend, are alſo paſſed through by multitudes of the moſt beautiful beings of the creation.

Every order of animals is fitted for its ſituation in life: but none more apparently than birds Though they fall below beaſts in the ſcale of nature, yet they hold

hold the next rank, and far ſurpaſs fiſhes and inſects, both in the ſtructure of their bodies and in their ſagacity.

The body of man preſents the greateſt variety: beaſts leſs perfectly formed, diſcover their defects in the ſimplicity of their conformation: the mechaniſm of birds is yet leſs complex: fiſhes are furniſhed with fewer organs ſtill; while inſects, more imperfect than all, fill up the chaſm between animal and vegetable nature. Of man, the moſt perfect animal, there are but three or four ſpecies; the kinds of beaſts are more numerous; birds are more various ſtill; fiſhes yet more; but inſects afford an immenſe variety.

In all birds, except nocturnal ones, the head is ſmaller, and bears leſs proportion to the body than in beaſts; that it may the more readily divide the air in flying. Their eyes alſo are more flat and depreſſed, and a circle of ſmall plates of bones, placed ſcale-wiſe under the outer coat of the organ, encompaſſes the pupil on each ſide to ſtrengthen and defend it from injuries. Beſide this, birds have a kind of ſkin, called the nictitating membrane, with which, like a veil, they can at pleaſure cover their eyes, though their eyelids continue open. This membrane ſerves alſo to wipe, cleanſe, and probably to moiſten its ſurface. The eyes, though they outwardly appear but ſmall, yet each almoſt equals the brain; whereas in man the brain is more than twenty times larger than the eye.

Hence it follows, that the ſenſe of ſeeing in birds is infinitely ſuperior to that of other animals. Indeed this piercing ſight ſeems neceſſary to the creature's ſupport and ſafety. Were it not ſo, from the rapidity of the bird's motion, it would be apt to ſtrike againſt every object in its way; and it could ſcarcely find ſubſiſtence, unleſs it could diſcern its food from above with aſtoniſhing ſagacity. A hawk, for inſtance, perceives a lark at a diſtance, which neither men nor dogs could ſpy; and a kite, from an almoſt imperceptible height darts down on its prey with the moſt unerring aim.

Granivorous birds, or ſuch as live upon vegetables, have their inteſtines differently formed from thoſe of the rapacious kind. Their gullet dilates juſt above the breaſt-bone, and forms itſelf into a pouch or bag, called

called the crop. This is replete with ſalival glands, which moiſten and ſoften the food it contains. After the dry food of the bird has been macerated, it paſſes into the belly, where, inſtead of a ſoft, moiſt ſtomach, as in the rapacious kinds, it is ground between two pair of muſcles, commonly called the gizzard, covered on the inſide with a ſtrong ridgy coat. Theſe coats rubbing againſt each other, are capable of attenuating the hardeſt ſubſtances; their action being often compared to that of the grinding teeth, in man and other animals.

Thus the organs of digeſtion are in a manner reverſed in birds. Beaſts grind their food with their teeth, and then it paſſes into the ſtomach, where it is ſoftened and digeſted. On the contrary, birds of this ſort firſt ſoften it in the crop, and then it is ground and comminuted in the ſtomach or gizzard. Birds are all careful to pick ſand, gravel, and other hard ſubſtances, not to grind their food, as has been ſuppoſed, but to prevent the too violent action of the coats of the ſtomach againſt each other.

To birds, the return of ſpring, is the beginning of pleaſure. Thoſe vital ſpirits which ſeemed locked up during the winter, then begin to expand; vegetables and inſects ſupply abundance of food; and the bird having more than a ſufficiency for its own ſubſiſtence, is impelled to transfuſe life as well as to maintain it. Thoſe warblings which had been huſhed during the colder ſeaſons, now begin to animate the fields; every grove and buſh reſounds with the challenge of anger, or the call of allurement. The delightful concert of the grove, which is ſo much admired by man, is no way ſtudied for his amuſement: it is the call of the male to the female; his efforts to ſooth her during the time of incubation: or a challenge between two males for the affections of ſome common favourite.

It is by this call that birds begin to pair at the approach of ſpring, and provide for the ſupport of a future progeny. The loudeſt notes are uſually from the male; the hen expreſſes her conſent, in a ſhort, interrupted twittering. Their compact holds with unbroken faith: moſt birds live with inviolable fidelity together; and when one dies, the other is always ſeen to ſhare

the

the ſame fate ſoon after. We muſt look for it in our fields and in our foreſts, where nature continues in unadulterated ſimplicity; where the number of males is generally equal to that of females. But the male of all wild birds is as happy in the young brood as the female. They both ſeem, at this ſeaſon, tranſported with pleaſure: every action teſtifies their tender ſolicitude.

But previous to laying, the work of neſtling becomes the common care: and this is performed with no ſmall degree of aſſiduity. It has been aſſerted, that birds of one kind always make their neſts in the ſame manner, and of the ſame materials; but the truth is, they vary this as the materials, places, or climates differ. The red-breaſt, in ſome parts of England, makes its neſt with oak leaves, where they are in plenty, and in other parts with moſs and hair. Some birds, that with us make a very warm neſt, are leſs ſolicitous in the warm climates. In general, however, every ſpecies of birds has a peculiar architecture of its own; and this adapted to the number of eggs, the temperature of the climate, or the heat of the animal's body. Where the eggs are numerous, the neſt is warm, that the animal's heat may be equally diffuſed to them all. Thus the wren, and all the ſmall birds make their neſts very warm; for having many eggs, it is requiſite to diſtribute warmth to them all: on the contrary, the plover, that has but two eggs, the eagle, and the crow, are not ſo ſolicitous in this reſpect, as their bodies are capable of being applied to the ſmall number upon which they ſit.

Nothing can exceed the patience of birds while hatching; neither hunger, nor danger, can drive them from the neſt. They are fat upon beginning to ſit, yet before incubation is over, are uſually waſted to ſkin and bone. Indeed ravens and crows, while the females are ſitting, take care to provide them with food in abundance. But it is different with moſt of the ſmaller kinds: during the whole time, the male ſits near his mate upon ſome tree, and ſooths her by his ſinging; and often when ſhe is tired takes her place, and patiently continues on the neſt till ſhe returns.

So

So great is the power of inſtinct in theſe animals, that they continue almoſt paſſive under its influence. Yet at the ſame time, the hen, that has all this ſeeming ingenuity, in other reſpects, is without the leaſt glimmerings of common ſenſe: ſhe miſtakes a piece of chalk for an egg, and ſits upon it in the ſame manner; ſhe is inſenſible of any increaſe or diminution in the number of thoſe ſhe lays; ſhe does not diſtinguiſh between her own, and thoſe of another ſpecies; and when the birth appears of never ſo different a bird, will cheriſh it for her own.

As the principle which acts in theſe animals cannot be termed reaſon, ſo when we call it inſtinct, we mean ſomething we have no knowledge of. It appears to me the immediate direction of providence; and ſuch an operation of the Supreme Being as that which determines all the portions of matter to their proper centres.

While the young are yet unfledged, the old one takes care to provide them with a regular ſupply: when the family is fully plumed, and capable of avoiding danger by flight; they are then led forth when the weather is fine, and taught the paternal art of providing for their ſubſiſtence. They are led to the places where their food lies; they are ſhewn the method of diſcovering or carrying it away; and then led back to the neſt, for a day or two longer. At length, when they are qualified to ſhift for themſelves, the old one takes them abroad, and leading them to the accuſtomed places, forſakes them for the laſt time; and all connection is at an end.

Birds in general, though they have ſo much to fear from man and each other, are ſeldom ſcared from their uſual haunts. The greateſt number remain contented, where they have been bred. The rook, if undiſturbed, never deſires to leave his native grove; the black-bird ſtill frequents its accuſtomed hedge; and the red-breaſt, though ſeemingly mild, claims a certain diſtrict, from whence he ſeldom moves, but drives out every one of the ſame ſpecies from thence without pity. They are excited to migrations by no other motives, but thoſe of fear, climate, or hunger. It is from one of theſe motives, that birds of paſſage, every year, forſake

forſake us for ſome time; and make their regular returns. The cauſe of their retreat is, either ſcarcity of food, or the want of an aſylum from man, during the time of courtſhip, and bringing up their young. Thus the ſtarling, at Sweden, at the approach of winter, finding ſubſiſtence no longer, deſcends into Germany; and the hen chaffinches of the ſame country are ſeen to fly every year through Holland, to paſs their winter in a milder climate. Others prepare for longer journeys. Thus the quails, in ſpring, forſake the heats of Africa, for the milder ſun of Europe; and when they have paſſed the ſummer with us, ſteer their flight to enjoy, in Egypt, the temperate air. This with them ſeems a pre-concerted undertaking. They unite together in ſome open place, for ſome days before their departure, and, by an odd kind of chattering, ſeem to debate on the method to proceed. Then they all take flight together, and often in ſuch numbers, that, to mariners at ſea, they ſeem like a cloud upon the horizon. The ſtrongeſt, and by far the greateſt number, make good their intention; but many there are, who grow weary in the way, and drop down into the ſea, and ſometimes upon the decks of ſhips.

Of the vaſt quantity of water-fowl, that frequent our ſhores, few are known to breed here. The cauſe that urges them to leave us ſeems to be, not merely the want of food, but the deſire of a ſecure retreat. Our country is too populous for birds ſo ſhy, as the greateſt number of theſe are. When great part of our iſland was an uncultivated tract of woods and marſhes, many ſpecies of birds, which now migrate, remained with us the whole year. The great heron, and the crane, that have now forſaken this country, in former times bred familiarly in our marſhes. Their neſts, like thoſe of moſt cloven-footed water-fowl, were built on the ground, and expoſed to every invader. But as rural œconomy increaſed, theſe animals were more and more diſturbed. Once they had little to fear, as the ſurrounding marſh defended them from all the carnivorous ſurrounding quadrupeds, and their own ſtrength from birds of prey; but by a long ſeries of alarms, they have, at length, been obliged to ſeek,

during the ſummer, ſome lonely habitation, at a ſafe diſtance from every deſtroyer.

Of the numerous tribes of the duck-kind, we know of no more than five that breed here. The reſt contribute to form that amazing multitude of water-fowl which annually repair to the dreary lakes and deſarts of Lapland, from the more ſouthern countries of Europe. In thoſe ſolitary retreats, they perform the duties of incubation and nutrition in full ſecurity. There are few of this kind that may not be traced to the northern deſerts; to countries of lakes, rivers, ſwamps, and mountains, covered with thick and gloomy foreſts. In thoſe regions, from the thickneſs of the foreſts, the ground remains moiſt and penetrable during the ſummer ſeaſon; the woodcock, the ſnipe, and other ſlender-billed birds, can there feed at eaſe; while the web-footed birds find more than ſufficient food from the number of inſects, which ſwarm to an incredible degree. The days there are long; and the beautiful nights afford them every opportunity of collecting ſo minute a food.

2. Birds have feathers which they expand in order to fly; the fine branches of which lie ſo cloſe together, that little air can inſinuate itſelf between them. Now when the column of air on which a body reſts is ſpecifically heavier than the body, it remains ſuſpended in the air; if it be lighter, the body ſinks. Hence, the larger ſpace a body circumſcribes, the more eaſily does the air ſuſtain it. Conſequently the ſame bird which ſinks when the wings are cloſed, is ſuſtained when they are expanded. To this alſo the motion of the wings contributes: (as a body while moving ſwiftly, will ſwim in water, which immediately ſinks, if that motion ceaſes.) And ſo do the feathers, with which their bodies are clothed, which increaſe their bulk, but not their weight in the ſame proportion.

The parts of birds chiefly concerned in flying, are the wings and the tail. By the firſt, the bird ſuſtains and wafts himſelf along. By the ſecond he is enabled to keep his body ſteady and upright, particularly in aſcending and deſcending. It is by the largeneſs and ſtrength of the pectoral muſcles, that they are qualified for

for flying. In men theſe are ſcarce a ſeventeenth part of the muſcles of the body. In birds they conſiderably outweigh all the other muſcles together. And this circumſtance alone, the want of ſuitable muſcles, makes all human attempts to fly, void and vain.

Nevertheleſs the art of flying has been ſeriouſly attempted by many, in various ages, particularly in the time of our famous Friar Bacon, who lived about 500 years ſince, and whom his excellent works ſhew to have been a rare chymiſt, an excellent mathematician, a knowing mechanic, and a moſt accompliſhed experimental philoſopher. Yet even he believed the art of flying poſſible, and ſays, he himſelf knew how to make an engine, in which a man ſitting might be able to convey himſelf through the air, like a bird. Nay he affirms, that there was then another perſon, who had actually tried it with ſucceſs.

In flying, the bird firſt bends his legs and leaps from the ground; then opens the joint of his wings, ſo as to make a right line, perpendicular to the ſides of his body. Being now raiſed and ſtrongly vibrating his wings, the air re-acts, as much as it is acted upon, and ſo protrudes his whole body. But in recovering his wing for freſh ſtrokes, it has a great reſiſtance to overcome. To elude this, the bony part of the wing, into which the feathers are inſerted, moves ſideways with its ſharp end foremoſt, and the feathers follow it like a flag.

All birds have near their tail a little bag, which contains oil, to moiſten their feathers. Geeſe have two glands for the ſecretion of this; other birds only one. In this are divers little cells ending in two or three large ones, lying under the nipple of the oil-bag. This nipple is perforated, and being preſt by the bird's bill, emits its oil.

In all birds that fly much, the wings are placed in the very beſt manner, to balance their bodies in the air, and to give as ſwift a progreſſion as they are ſeverally capable of. Otherwiſe they would reel and fly unſteadily; as we ſee they do, if we deſtroy their equipoiſe, by cutting one of their wings.

And what nicety may we obſerve, in a part no more conſiderable, than the vanes of the flag-feathers of the

wing!—1. The edges of the exterior or narrow vanes bend downward, but the interior, wider vanes upward. By this means they catch hold and lie close to each other, when the wing is spread; that not one feather may miss its full force and impulse upon the air. 2. Equal nicety is observed in the very sloping the tips of the flag-feathers: the interior vanes are neatly sloped away to a point, toward the outward part of the wing. The exterior, (at least in many birds) are sloped toward the body. And in the middle of the wing, the vanes being equal, are but little sloped. So that the wing, whether open or shut, is as neatly sloped, as if constantly trimmed with a pair of scissars.

The vane consists not of one continued membrane, because if once broke, it would not easily be repaired; but of many laminæ, which are thin, stiff, and something resembling a thin quill. Toward the shaft of the feather (especially in the flag-feathers of the wing) these laminæ are broad and of a semicircular form, which serves for strength, and for shutting them close together, when impulses are made on the air. Toward the outer part of the vane, they grow slender and taper. On their under side they are thin and smooth; but their upper, outer edge is parted into two hairy edges.

As curiously made are the feathers in the wing, and no less curiously placed, exactly according to their several lengths and strength; and these again are lined, faced, and guarded with covers and secondary feathers, to keep the air from passing through and so eluding the impulse.

How admirably wrought are the bones of the wing! very strong, but light withal; the joints, which open, shut, and move every way, as occasion is; and the various muscles, all suited to the motions which they minister to.

Next to the parts for flight, let us view the legs and feet, which minister to their other motions; both made light, for their easier passage through the air, and the latter, some with membranes for swimming, some without, for steady going, for perching, for catching and holding their prey, or for hanging by the heels to gather their food: the legs, all curved, for their easy perching or roosting, as also to help them upon their wings,

wings, in taking their flight. In ſome they are long, for wading and ſearching the waters; in others, if need be, remarkably ſhort. And how wiſely are they placed! In all, ſomewhat out of the centre of the body's gravity: but in ſuch as ſwim, more than in others, for the better rowing their bodies; as alſo to help them in diving.

Geeſe and ducks, their bodies being made for ſwimming, have their wings too placed out of the centre of gravity, nearer the head: but the extending the neck and head in flight, balances the body upon the wings: which is another excellent uſe (beſide ſearching for food) of the long necks of theſe birds.

But in the heron, whoſe head and long neck (although tucked up in flight) overbalances the hinder part of the body; the long legs are extended, both to counterpoiſe the body, and to ſupply what is wanting in the tail.

It has been ſuppoſed, that the flying of birds is analogous to the rowing of veſſels. But it is a motion of quite another kind. Oars are ſtruck toward the ſtern: whereas birds do not vibrate their wings toward the tail, but waft them downward. Nor does the tail cut the air (as the rudder does the water) at right angles, but horizontally. It likewiſe keeps the ſame ſituation which way ſoever the bird turns.

It is not therefore by the tail, that moſt birds turn to the right hand or the left, but by the wings. They turn to the right, by beating the air with the left wing alone toward the tail: to the left, by beating it with the right wing. Thus pigeons * changing their courſe toward

* It is a remarkable uſe which is made of pigeons, in the eaſtern countries. They are trained up in Turky and Perſia, to carry expreſſes; being firſt uſed to ſhort flights, afterwards to longer, till at length they will return from the farthest part of the kingdom. Yea, if they are brought hood-winked twenty or thirty miles, nay, ſixty or a hundred, they will find their way in a very little time, to the place where they were bred. Every Bashaw has a basket of theſe pigeons bred at the ſeraglio; one of which he diſpatches thither on any emergent occaſion, with letters braced under her wings. This proves a more ſpeedy method, as well as ſafer, than any other. For one of theſe birds will carry a letter from Babylon to Aleppo, which is thirty days journey, in forty-eight hours.

toward the left, labour with the right wing, ſcarce ſtirring the other.

Birds with long necks have another way of altering their courſe, by only inclining their head and neck this or that way.

Birds rarely fly up or down perpendicularly, but rather in a crooked line. In aſcending directly, the natural and artificial tendency would counteract each other. In deſcending directly, both would concur, and endanger too precipitate a motion.

Only the hawk ſtoops directly to ſeize its prey: whereas other birds in deſcending, retard the motion by keeping their wings expanded, and at the ſame time ſtretching out their feet and legs.

There is no flying animal, but has feet as well as wings; becauſe there is no food or at leaſt not food ſufficient for them, to be had always in the air. But if there were, yet ſuch birds could take no reſt; for having no feet, they could not perch upon trees. And if they alighted on the ground, they could not raiſe themſelves again: which birds that have ſhort feet can hardly do. Beſide, they would want means of breeding, having no way to lay their eggs, to ſit, hatch, or brood their young.

Before we conclude this head, it may be obſerved, that all the parts of birds are fitted for the uſe of flying. Firſt, as the muſcles of the wings are peculiarly ſtrong, ſo the under ſide of them is made concave, and the upper convex, that they may be the more eaſily lifted up, and the more ſtrongly ſtrike the air.—Then the trunk of their body ſomewhat reſembles the hull of a ſhip; the head, the prow; which is generally ſmall, that it may the more readily cut the air, and make way for the body. Add to this, that the bodies of birds are ſmall in compariſon of beaſts, that they may be more eaſily ſupported by the air. And they are not only ſmall, but of a broad figure, that they may be buoyed up the better. They are alſo hollow and light: yea, their very bones are light. For even thoſe of the legs and wings have ample cavities: by this means alſo they become rigid and ſtiff: it being demonſtrable, that a hollow body is more ſtiff and inflexible,

flexible, than a ſolid one of equal ſubſtance. The ſhafts alſo of the feathers are either empty, or filled with a light and ſpungy matter. And their webs conſiſt of two rows of contiguous filaments furniſhed all along with hooks on each ſide, whereby catching hold of one another they ſtick faſt together.

As to their tails, although it is true, as was obſerved, that all birds whoſe tails are pointed and end in a right line, turn themſelves by their wings and not their tails, yet in thoſe that have forked tails it is otherwiſe. Thus it is manifeſt to ſight, that the forked-tailed kite, by turning her train ſideways, raiſing one horn, and depreſſing the other, turns her whole body.—And doubtleſs the tail has the ſame uſe in ſwallows, who have all forked tails, and make more ſudden turns in the air than any other bird.

To lighten birds ſtill farther, they have large membranes extending to the bottom of their bellies, into which the air is received, where, by the heat of the body it is expanded into twice or thrice the dimenſions of the external air. And this they can either compreſs by the muſcles of the abdomen, or expire more or leſs, in order to their deſcending ſwifter or ſlower, in what degree they pleaſe.

3. As to the brain of birds, whereas in men the cortical part of the brain is outermoſt, in birds it is innermoſt, and the membrane that covers the upper ventricle is medullary. The ventricles likewiſe are ſituated above, near the upper part of the ſcull.

Perhaps before we proceed, it may be well to premiſe one general obſervation, that the ſtructure of birds is in many reſpects different from thoſe both of men and beaſts; having ſeveral parts which theſe want, and wanting others which they have. Beſides, there are great variations in the contrivance of parts which are common to both: all wiſely adapted to their different conditions and manner of life.

Parts

Parts peculiar to birds are, 1. Thebill. 2. The membrane to draw over the eyes. 3. Feathers and wings. The parts wanting in birds are, 1. Teeth and lips. 2. The bladder, which they do not need, as they drink no more than juſt to moiſten their food. Variations in the parts of birds from thoſe of men and beaſts, are, 1. In the ear, which is of a very peculiar make. 2. In the diviſion of the aorta. 3. In the ſpinal marrow, which is divided into two in the middle of the back. 4. In the bones, which are all hollow. 5. In the heart, which has a fleſhy valve at the mouth of the vena cava. 6. In the lungs, which are ſtrongly joined to the back, for the greater conveniency of flight. 7. In the ſtomach: birds have two or more, to ſupply the want of chewing. 8. In the legs and feet. 9. In their tails. 10. In their pectoral muſcles, which are the ſtrongeſt of all; whereas in man, the crural muſcles are the ſtrongeſt. 11. In the brain, as was before obſerved. 12. In the bronchia, which extends to the very bottom of the abdomen, ſo as to contain a large quantity of air. 13. In the ovaries, which in birds are ſingle, and faſtened on their back.

4. The ears of birds differ much from thoſe both of men and beaſts. There is almoſt a direct paſſage from ear to ear: ſo that if the drum be pricked in either ear, water poured in at one ear, will run out at the other. And what is ſtill more remarkable, they have a ſmall winding paſſage, that opens into a large cavity, running betwixt two ſculls, and paſſes all round the head. The upper of theſe ſculls is ſupported by many hundreds of ſmall, thread-like pillars; which have another uſe alſo, to break their ſound, and hinder its making a confuſed echo.

This paſſage between the two ſculls is much larger in ſinging-birds than in others. So that a perſon who has been ſhewn this, may hereby know them from all others.

The other organs of ſenſe are nearly the ſame in birds as in other animals, Only there is a difference in the organ of ſmell. The noſtrils lie on each ſide of the

the beak, in the inner part whereof, beſide the tube which reaches to the lungs, there are little tubes, continued from the membranes and ſubſtance of the brain. And theſe ſeem to be the organ of ſmell. Only two nerves paſs through the os cribroſum to the beak: leſt if there were more perforations, as in other animals, too much air might flow into the brain.

The bill of birds is peculiarly remarkable. In the firſt place, it is neatly ſhaped for piercing the air. In the next, it is hard and horny, to ſupply the want of teeth, and alſo in ſome meaſure, of a hand. Its hooked form is of great uſe to rapacious birds, in catching and holding their prey; and to others, in climbing, and in taking and comminuting their food.* Its extraordinary length and ſlenderneſs is of uſe to ſome, to ſearch for their food in mooriſh places:† as its length and breadth is to others, to hunt and ſearch in muddy places.‡ The contrary form, a thick, ſhort, and ſharped-edged bill is as uſeful to all other birds, who muſt huſk the grain they ſwallow. But it would be endleſs to reckon up all the ſhapes and commodious mechaniſm of all: the ſharpneſs and ſtrength of thoſe that have occaſion to perforate woods and ſhells;§ the ſlender-

 neſs

* Parrots have their bills nicely adapted to these services, being hooked, for climbing and reaching what they want, and the lower jaw so exactly fitted to the hook of the upper, that it will break the food, as other creatures do with their teeth.

† As to woodcooks and snipes, who hunt for worms in moorish ground; and likewise suck the unctuous humour out of the earth. So also the bills of curlews, and other sea-fowl, are very long, to enable them to hunt for worms, &c. in the sands.

‡ Ducks, geese, and divers other species of birds, have bills both long and broad, whereby they are enabled to quaffer in the water or mud, till they find their food.

§ The green woodspite, and all woodpeckers have strong and sharp bills, curiously made for digging wood. An even ridge runs along to the top of the green woodpecker's bill, as if an artist had designed it at once for strength and neatness.

Woodpeckers have also a tongue, ending in a sharp, bony rib, dented on each side, which they can at pleasure shoot out to a great length, and trust into the holes, clefts and crannies of trees. They strike them likewise into ant-hills, and fetch out the ants and their eggs. Moreover, they have short, but strong

legs,

neſs and neatneſs of ſuch as pick up ſmall inſects: the croſs form of ſuch as break up fruits;* the compreſſed † form of others, with many other curious forms, all ſuited to the occaſions of the ſeveral ſpecies.

In the flat-billed birds, as ducks, there are three pair of nerves, which come down between the eyes in the upper bill, whereby they are enabled to ſmell and find out their food in the mire or water. The like have been obſerved in ſeveral round-billed birds, but ſo ſmall as to be ſcarce diſcernable enough: and it is remarkable that theſe, more than any other round-billed birds, grope for their meat in cow-dung, and the like.

5. Of their lungs it is obſervable, that they are not only larger in proportion than thoſe of beaſts, but they admit the air, both above and beneath, by which means they become far lighter.

A duck is furniſhed with a peculiar ſtructure of veſſels, which enables it to live ſome time under water. Yet ſhe cannot live without air. One that was put into the air-pump, and the air exhauſted, ſeemed to bear it better for a few moments than any other fowl. But in leſs than two minutes her head fell down, and ſhe appeared dying, till revived by letting in the air.

A young, callow duck being tried in the ſame manner, was near death in leſs than two minutes. It is obſervable both of them ſwelled extremely, on pumping out the air. It not being intended, that water-

legs, and their toes ſtand, two forward, two backward: a diſpoſition which is particularly convenient for the climbing of trees. In this they are likewiſe aſſisted by the uncommon ſtiffneſs of the feathers of their tails, and by their bending downward, whereby they are fitted ſo ſerve them as props to lean on.

* The croſs-bill, whoſe bill is thick and ſtrong, with the tips croſſing each other, readily breaks open fir-cones and other fruits, to come at and feed on the kernels. And undoubtedly the croſſing of the bill was deſigned for this very ſervice.

† The ſea-pye has a long, ſharp, narrow bill, compreſſed ſidewiſe, and every way adapted to the raiſing limpets from the rocks, which are its chief, if not only, food.

fowl

fowl ſhould live in an exceeding rarified air, but only continue under water, they are qualified for this, but not at all for the other.

Yet that ducks can live almoſt any where, we may learn from the blind ducks of the Zerchintzer lake in Carniola, a territory in Auſtria. This communicates with another lake under ground in the mountain Savornick, and fills or empties itſelf according to the fullneſs or emptineſs of that. The waters of the upper lake, when it empties, run off by large holes in the bottom. The ducks which are very plentiful in the water, are often carried down with it into the ſubterraneous lake. In this many of them undoubtedly periſh; yet ſome remain alive. But they looſe their ſight and their feathers: and at the next filling of the upper lake, both they and vaſt numbers of fiſh are thrown up with the water. They make a ſtrange appearance in their naked ſtate; and for want of ſight are eaſily caught. In about a fortnight they recover their ſight and their feathers, and are then as big as common wild-ducks. At their firſt coming up, their ſtomachs are full of ſmall fiſhes, and ſomething reſembling weeds. It ſeems therefore, they were not quite blind, when in their dark habitation, but could ſee by that ſmall quantity of light, to ſearch for and find their food.

Nor is it in this lake only that theſe ducks are found. They are frequently thrown up, after great rains, at a hole in a mountain, near the town of Laon, in the Iſle of France. The water then guſhing out with great violence, brings theſe blind and bald creatures with it. And their frequency and cheapneſs, from the vaſt quantities which are thrown out, make them eſteemed no variety.

The bodies of duckers or loons are admirably fitted for diving: being covered with a thick plumage, and the ſurface of it ſo ſmooth, that the water cannot penetrate it. Hereby their bodies are defended from the cold, the water being kept at a diſtance; and are ſo poiſed, that by a light impulſe, they eaſily aſcend in it.

it. Again, their feet are ſituate in the hindmoſt part of their body, ſo that ſhooting them backward and ſtriking the water upwards, they plunge themſelves down with great eaſe, and move forward therein.— Their legs alſo are made flat and broad, and their feet cloven into toes, with appendant membranes on each ſide. By this configuration they eaſily cut the water, and are drawn forward, to take their ſtroke backward: and by this, their feet being moved to the right or left, ſerve them as a rudder to turn under water.— How they riſe above water is not determined: whether by their natural lightneſs, or by ſtriking againſt the bottom, in the manner of a leap, or by ſome peculiar motion of the legs. That they dive to the bottom, is undeniable. For in the ſtomachs, both of the greater and leſſer kind, we find much graſs and other weeds; and in the leſſer kind, little elſe. Yet both prey upon fiſh; and their bills are ſtraight and ſharp, for the eaſier ſtriking their prey.

It is likewiſe remarkable, that whereas in other animals the lungs are looſe and have much play, in all birds they adhere to the thorax, and have little play. This is a good proviſion for their ſteady flight. Alſo they want the diaphragm, and inſtead thereof have divers large bladders, made of thin, tranſparent membranes, with pretty large holes, out of one into the other. Theſe membranes ſerve for braces to the viſcera, as well as to contain air. Toward the upper part, each lobe of the lungs is perforated in two places with large perforations; whereof one is toward the outer, the other toward the inner part of the lobe. Through theſe perforations the air has a paſſage into the fore-mentioned bladders; ſo that by blowing into the windpipe, the lungs are raiſed, and the whole belly blown up. This doubtleſs is a means to make them more or leſs buoyant, as they take in more or leſs air: and ſo anſwers the deſign of the air-bladder in fiſhes.

In general we may obſerve, whatever is peculiar in the wings, bills, and every other part of birds, on a cloſe inſpection will be found exactly ſuited to their wants. They are a ſet of implements nicely proportioned

tioned to their manner of life. To inſtance in a few, ſparrows and moſt ſmall birds, are ſupported by the little grains they find up and down. They have no effort to make, to obtain their food, or break it in pieces, and therefore have a ſmall bill, as well as ſhort necks and legs, which are ſufficient for their purpoſes. But the woodcock, ſnipe, curlew, and many other birds, ſeek their food deep in the earth or ſlime. Therefore they are provided with a long neck and bill, and with theſe they dig and ſearch and want for nothing. The woodpecker, who lives in a quite different manner, is as differently formed. His bill is very long, ſolid, and ſtrong: his tongue is ſharp, and extremely long; beſide which, it is armed with little points, and covered with glue toward the extremity. He has ſhort legs, two talons before, two behind, and all very crooked. All this equipage ſuits his manner of living. His food is worms or inſects, that live in the heart or branches of trees, or under the bark of old wood; frequently they are ſunk very deep, under the bark of large billets. The woodpecker has hooked claws, to graſp theſe branches; and a ſtrong and pointed bill, to find out by darting it up and down, what parts of them are rotten. When he has found out theſe, he with his bill, ſhatters the bark and wood. He then ſends forth a loud whiſtling cry, into the cavity, to alarm the inſects and put them in motion. Next he darts in his tongue, and by the ſmall points which ariſe out of it, and the glue that covers it, draws out whatever lodged there.

The heron, on the contrary, mounts aloft. His legs and thighs are very long, and bare of feathers. He has a great length of neck, and an enormous bill, very ſharp and jagged at the end. What reaſon can be aſſigned for a figure, which at firſt ſight ſeems ſo extravagant? He feeds on frogs and ſmall ſhell-fiſh, as well as other fiſh, which he finds in fens, or bogs, or near the ſhores of rivers. He wants no feathers on his thighs, to walk through water and ſlime; but he needs very long legs, to run in the water, along the ſhores, whither the fiſhes reſort for their food. A long neck and bill qualify him for purſuing and ſeizing his

prey

prey at ſome diſtance: and the jaggs of his bill enable him to hold the fiſh, which would otherwiſe ſlide away. In fine, his large wings, which ſeem incommodious to a bird of ſo ſmall a body, are abſolutely needful for his making ſo great movements in the air, and conveying ſuch burdens to his neſt, which is frequently two or three leagues diſtant from the place where he fiſhes.

The imperfections therefore which we imagine we diſcover, in this (as in many other animals) in reality belong only to our own underſtanding, and all our cenſures of the works of nature, are in truth, only ſo many indications of our own ignorance.

6. The ſtomach (eſpecially of granivorous birds,) is of a peculiar ſtructure. Firſt, there is a glandulous receptacle, wherein the grains are kept for ſome time. They are then received into another ſtomach, conſiſting of two muſcles, and a callous membrane. One of theſe moves obliquely downward, and the other upward. Hereby the ſhell of the grain is broke, and the meal expreſſed and mixt with proper juices. The aliments thus prepared, fall into the bottom of the ſtomach, where they are purged again from the refuſe: to which end that part is a little raiſed, that the corn may not paſs out too ſoon. There is alſo a partition, which divides what is already digeſted from the reſt.

As birds have no bladder, in the room of urine, a whitiſh excrement is diſcharged from the kidneys into the rectum.

7. The generation of birds is not well known. In the ovary, placed between the liver and the backbone, a great number of yolks are contained; one of which when impregnated, paſſes through the oviduct into the womb, where it receives the white and the ſhell, and remains till it comes to its full ſize. The parent then broods over it, till the young being gradually formed, perfected, and quickened, burſts the ſhell.

Under

Under the ſhell of an egg lies the common membrane, adhering cloſely to it, except at the bigger end, where a little ſpace is left between them. This membrane contains two whites, each encloſed in its own membrane. In the middle of the inner white is the yolk, encloſed likewiſe in a ſeparate cover. The outer white is oval, the inner round, (as is the yolk) and of a more viſcid ſubſtance.

At each end is a chalaza, a white, denſe body, conſiſting of three little globules, like grains of hail, (ſo the word ſignifies) all joined together. Theſe ſerve both to knit the ſeveral membranes together, and to keep the liquors in their proper places and poſition.

About the middle of the ſmall end of the yolk, is a little yellowiſh bladder, like a vetch, called the cicatricula or eye of the egg. This contains a humour, in and out of which the young bird is generated. The white ſerves it for food, till it becomes big; then the yolk, and likewiſe after it is hatched. For even then a good part of the yolk is lodged in its belly, as in a ſtore-houſe, and being conveyed thence by the inteſtinal duct into the bowels, ſerves it inſtead of milk.

An egg, improperly ſo called, is that, of the whole whereof the animal is formed. Such are the eggs of flies. Proper eggs, when excluded, need no external nutriment. Of proper eggs, ſome are perfect, that is, have all the parts above deſcribed, while in the ovary or womb: ſome imperfect, which have them not, till after they are excluded; as thoſe of fiſhes, which aſſume a white in the water.

An egg, not impregnated by the male, will never breed young, but always putrify. One impregnated contains the rudiments of the bird, even before incubation. By the microſcope we ſee the plain carina or ſpine of it ſwimming in the middle of the cicatricula, conſiſting of fine, white threads, which incubation gradually perfects.

The air-bag is very ſmall in a new-laid egg, but becomes

comes larger, when the egg is kept. The yolk is ſpecifically heavier than the white. Hence its ſmaller end is always uppermoſt, in all poſitions of the egg.

After incubation, the air-bag gradually extends, till near the hatching; it takes up a third of the egg. By incubation the white becomes thinner and more turbid, eſpecially near the air-bag, where it is firſt conſumed. Then it leſſens towards the ſharp end of the egg, till nothing is left, but a white, chalky ſubſtance. The white of an impregnated egg is as ſweet all the time of incubation as that of a new-laid egg. They are only unimpregnated eggs, vulgarly called wind-eggs, which putrify and ſtink.

The yolk alſo remains freſh and uncorrupted all the time of the incubation. It is depreſt in the middle, as the chick grows, and is ſoon brought into a form, not much unlike that of a horſe-ſhoe, in the middle of which the chick lies.

Not long before the chick is hatched, the whole yolk is taken into the abdomen.

The eye or tread, in which the chick lies, is ſoon enlarged by incubation, and riſes to the upper part of the egg. The heart and umbilical veſſels, are ſome of the firſt parts, which we are able to diſtinguiſh.

The embryo is ſeen at firſt like a ſmall worm. Then its carina or ſpine appears, with the large prominencies that afterward ſhew themſelves to be the brain and eyes. The other bowels ſeem hanging from the ſpine. Then the chaſm of the mouth is diſcovered. The extremities ſprout out. The bowels are gradually covered with the teguments. At laſt the beak, nails, and feathers are ſeen. When all its parts are formed, the chick is always found lying on its ſide, with its neck bent forward, the head covered with the upper wing, and the beak placed between the thighs.

The birds which nouriſh their young, have commonly very few. On the contrary, thoſe whoſe young

feed

ſeed themſelves when they firſt ſee the day, have ſometimes eighteen or twenty at a brood. This prudence could only ſpring from Him, who regulates all things to the beſt advantage. Were thoſe who provide for their young to have ſo numerous a brood, both the parents would be ſlaves, and yet the young but ill accommodated. Whereas the mother, who only marches at their head, without nouriſhing them, can conduct twenty as well as four.

But when they firſt make their appearance, what care do the parents take, till their young can ſubſiſt without them? Of thoſe that feed their young, the linnet and the nightingale then labour like the reſt. Sometimes one parent goes in queſt of proviſions, ſometimes the other, and ſometimes both. They are up before the ſun. And the food they have procured, they diſtribute with great equality, giving each a portion in its turn, before ever they feed one bird twice.

And this tenderneſs for their offspring is ſo ſtrong, as even to change their natural diſpoſition. Follow the hen when ſhe is the parent of a family, and ſhe is no longer the ſame creature. She is no longer ravenous and inſatiable. If ſhe finds but a grain of corn or a crum of bread, ſhe never touches it herſelf, but calls her troop, by a note they well underſtand, and divides it among them. She is no longer timorous, but at the head of her young, will ſpring even at the ſtouteſt dog.

When the turkey-hen appears at the head of her young, ſhe ſometimes utters a mournful cry, and they immediately run under buſhes, furze, or whatever preſents itſelf. She looks upward, and repeats her cry: which is occaſioned by her ſeeing a bird of prey, though ſo diſtant, that he appears unto us, only as a dark point under the clouds. But he no ſooner diſappears, than ſhe utters another cry, which revives all her brood. They run to her, flutter their wings, and ſhew all the tokens of joy. Now, who apprizes her of an enemy, that never yet committed any act of hoſtility in the country? And how is ſhe able to diſcover him, when

at

at ſo great a diſtance? How are her family inſtructed, to underſtand her different cries, and regulate their behaviour accordingly? What wonders are theſe which are daily obvious to our view, though we treat them with inattention?

An amazing degree of natural inſtinct, or underſtanding, God has imparted to birds of paſſage. They fly in troops, often in the form of a wedge, with the point foremoſt. They ſteer their courſe through unknown regions, without either guide or compaſs. And they are peculiarly accommodated for their flight, by the ſtructure of their parts.

In the act of migration, it is highly remarkable, 1. That they know (as the ſcripture ſpeaks) their appointed times, when to come and when to go. Appointed by whom? Surely by the great Creator, who has imprinted on their nature an inclination, at ſuch a time to fly from a place that would obſtruct their generation, or not afford food for them and their young, and betake themſelves to another place, which will afford all that is wanting.

It is highly remarkable, 2. That they know whither to go, and which way to ſteer their courſe! That they ſhould be directed yearly to the ſame place, perhaps to a little iſland, as the Baſſe in Edinburgh-Frith. How came land-birds to venture over a vaſt ocean, of which they can ſee no end? And how do they ſteer their courſe aright to their ſeveral quarters, which before the compaſs was invented, man himſelf was not able to do? They could not poſſibly ſee them at that diſtance. Or if they could, what ſhould teach or perſuade them that that land is more proper for their purpoſe than this? That Britain, for inſtance, ſhould afford them better accommodations, than Egypt, than the Canaries, than Spain, or any other of the intermediate places?

But it has been commonly ſuppoſed that ſeveral birds are of this number, becauſe they diſappear in winter, which really are not; cuckoos, for inſtance, and ſwallows:

lows: for neither of theſe ever croſs the ſeas. Cuckoos lodge all the winter in hollow trees, or other warm and convenient cavities. And ſwallows have been found in vaſt quantities, clung together in a lump, like ſwarms of bees, but utterly cold and ſenſeleſs, even in ponds that have been cleaned out, hanging under the water.

I know not how we can doubt of this fact, that ſwallows have been found in winter, under water, clung together, atteſted by men of unqueſtionable veracity. And yet others affirm, that they have ſeen flights of ſwallows croſſing the ſea in autumn. The truth ſeems to be this. There are ſome ſpecies of ſwallows, which ſeek a warmer climate at the approach of winter, while others remain here in a temporary death, like the flies on which they feed.

They have in Virginia, a martin like ours, only larger, which builds in the ſame manner. Col. Bacon obſerved for ſeveral years, that they conſtantly came thither upon the tenth of March. Two of them always appeared a day or two before, hovering in the air. Then they went away, and ſpeedily returned, with the whole flock.

The following ſeems to be a very rational account of moſt of thoſe that are really birds of paſſage.

When by the approach of our winter their food fails, birds of paſſage are taught by inſtinct to ſeek it elſewhere. Want of food ſeems to be the chief reaſon of their migration. The length of their wings enables them to catch the flying inſects, with which the air is ſtored during the warm months. And moſt ſummer birds of paſſage, feed on the wing upon ſuch inſects as are ſeen no more when winter comes. If it be conſidered, how much of the globe ſtill remains unknown, it is no wonder we are not yet acquainted with the places to which they retire. Probably they lie nearly in the ſame latitude in the ſouthern hemiſphere, as thoſe from whence they depart.

As ſwallows cannot bear ſo much cold, as ſome other birds of paſſage, they are conſtrained to viſit us ſomewhat later, and to depart ſomewhat ſooner. Some

ſtay

ſtay a month after them. Probably many of them perform their long journies chiefly in the night. Lying on the deck of a ſloop on the north ſide of Cuba, I and the company with me heard three nights ſucceſſively, flights of rice-birds (their notes being plainly diſtinguiſhable) paſſing over our heads northerly, which is their direct way from the ſouthern continent of America, from whence they go yearly when the rice begins to ripen, and after growing fat, return back.

There are alſo winter birds of paſſage, which arrive here in autumn and go away in ſpring, namely, the fieldfare, redwing, woodcock, and ſnipe. But the two latter ſometimes ſpend the whole year here. Whereas the two former conſtantly at the approach of ſummer, retire to more northern climates, where they breed, and remain till at the return of winter, they return to us again.

The winter food of theſe birds being berries and haws, which are far more plentiful here than in more northern regions, this is one reaſon of their coming over: but the principal is, the ſeverity of the weather in thoſe climates, which nature teaches them to exchange, for ſuch as are more temperate. But why do they depart from us in ſpring? This ſtill remains among the ſecrets of nature.

Beſide theſe ſummer and winter birds, there are others which come periodically to certain places, for the ſake of ſome ſort of food, which their own country is deſtitute of. Theſe quickly depart, and are ſeen no more till that time twelvemonth. Such are the rice-bird and blue-wing of Carolina.

But above half a century paſſed, from the time of cultivating rice and wheat in Carolina and Virginia, before theſe foreign birds made their appearance there. The wheat birds now come annually to Virginia, when the wheat ripens, and have come every year, ſince their firſt appearance, in numerous flights.

The ſpecies of birds already known, amount to about eight hundred. Linnæus divides them into ſix claſſes; namely, into birds of the rapacious kind, birds of the pie kind, birds of the poultry kind, birds of the ſparrow kind, birds of the duck kind, and birds of the

crane

crane kind. The four firſt comprehend the kinds of land birds; the two laſt, thoſe that belong to the water.

In beginning with the feathered tribe, the oſtrich ſeems to unite the claſs of beaſts and of birds in itſelf. While it has the general outlines and properties of a bird, it retains many of the marks of a beaſt. In appearance it reſembles the camel, and is almoſt as tall; it is covered with a plumage that reſembles hair much more than feathers, and its internal parts bear as near a ſimilitude to thoſe of the beaſt as of the bird creation. It may be conſidered, therefore, as an animal made to fill up that chaſm in nature which ſeparates one claſs of beings from another. It is uſually ſeven feet high, from the top of the head to the ground. The external eye is like that of a man, the upper eye-lid being adorned with eye-laſhes which are longer than thoſe on the lid below.

They inhabit the moſt ſolitary deſarts, where there are few vegetables, and where the rain never comes. The Arabians aſſert, that the oſtrich never drinks; and the place of its habitation confirms the aſſertion. In theſe regions, oſtriches are ſeen in large flocks, which to the diſtant ſpectator appear like a regiment of cavalry. The oſtrich is of all other animals the moſt voracious. It will devour leather, hair, graſs, iron, ſtones, or any thing that is given. But thoſe ſubſtances which the coats of the ſtomach cannot ſoften, paſs whole; ſo that hair, ſtones, and iron, are excluded in the form in which they were devoured.

In their native deſarts, however, they live chiefly upon vegetables, where they lead an inoffenſive and ſocial life; the male, as Thevenot aſſures us, aſſorting with the female with connubial fidelity. They lay generally from forty to fifty eggs. It has been commonly reported, that the female depoſits them in the ſand; leaves them to be hatched by the heat of the climate, and then permits the young to ſhift for themſelves. Very little of this, however, is true: no bird has a ſtronger affection for her young; none watches her eggs with greater aſſiduity. Indeed, in thoſe hot climates, there is no neceſſity for the continual incubation of the female; but though the female forſakes

her

her eggs by day, ſhe carefully broods over them by night. Then they ſit on their eggs like other birds, and the male and female take this office by turns. Nor do they forſake their young after they are excluded the ſhell. On the contrary, the young ones are not even able to walk for ſeveral days after they are hatched. During this time, the old ones are very aſſiduous in ſupplying them with graſs, and very careful to defend them from danger: nay, they encounter every danger in their defence.

All land-birds of the rapacious kind, are furniſhed with a large head, and ſtrong crooked beak, notched at the end, for the purpoſe of tearing their prey. They have ſtrong ſhort legs, and ſharp crooked talons for the purpoſe of ſeizing it. Their bodies are formed for war, being fibrous and muſcular; and their wings for ſwiftneſs of flight, being well feathered and expanſive. The ſight of ſuch as prey by day is aſtoniſhingly quick; and ſuch as ravage by night, have their ſight ſo fitted as to ſee objects in darkneſs. Thus formed for war, they lead a life of ſolitude. They inhabit, by choice, the moſt lonely places. They make their neſts in the clefts of rocks, and in the higheſt and moſt inacceſſible trees of the foreſt. Whenever they appear in the cultivated plain, it is only for the purpoſes of depredation: and they ſpread terror wherever they approach: all the variety of muſic, which but a moment before enlivened the grove, at their aproach is at an end: leſſer birds ſeek for ſafety, either by concealment or flight; and ſome are even driven to take protection with man, to avoid their leſs merciful purſuers.

It would indeed be fatal to all the ſmaller race of birds, if, as they are weaker than all, they were alſo purſued by all: but it is contrived wiſely, that every order of carnivorous birds ſeek only for ſuch as are of a ſize approaching their own. The eagle flies at the buſtard or the pheaſant, the ſparrow-hawk at the thruſh and the linnet. And nature has provided that each ſpecies ſhould make war only on ſuch as are furniſhed with adequate means of eſcape. The ſmalleſt birds avoid their purſuers by the extreme agility, rather than the ſwiftneſs of their flight; for every order would

ſoon be at an end, if the eagle, to its ſwiftneſs of wing, added the verſatility of the ſparrow.

Another circumſtance which tends to render the tyranny of theſe animals more ſupportable, is, that they are leſs fruitful than other birds. Thoſe of the larger kind ſeldom produce above four eggs, often but two; thoſe of the ſmaller kinds, never above ſix or ſeven. Likewiſe the carnivorous kinds only breed annually, and of conſequence their fecundity is ſmall.

8. The largeſt of birds is the cuntur of Peru. The body is as big as that of a ſheep. Its wings extended are fifteen or ſixteen feet from point to point. It is never ſeen in foreſts, becauſe it would not have room to fly, but frequents the ſea-ſhore and the banks of rivers. Nature, to allay their fierceneſs, has denied them the talons given to eagles, though they are of the eagle-kind. However, their beak is ſtrong enough to tear off the hide, and rip up the bowels of an ox.

What a bleſſing is it to mankind, that there are but few (juſt enough to keep up the ſpecies) of this monſter in the feathered creation! And into what can we reſolve this, but the wiſe and over-ruling care of an adorable providence?

In beaſts the ſmalleſt animals are noxious, and loathſome; the ſmalleſt of birds are the moſt beautiful, innocent, and ſportive. Of all thoſe that flutter in the garden, or paint the landſcape, the humming-bird is the moſt delightful to look upon, and the moſt inoffenſive.

Of this there are ſix or ſeven varieties, from the ſize of a ſmall wren, down to that of an humble bee. An European could never have ſuppoſed a bird exiſting ſo very ſmall, and yet completely furniſhed out with a bill, feathers, wings, and inteſtines, exactly reſembling thoſe of the largeſt kind. A bird not ſo big as the end of one's little finger, would probably be ſuppoſed but a creature of imagination, were it not ſeen in infinite numbers, and as frequent as butterflies in a ſummer's day, ſporting in the fields of America, from flower to flower.

The ſmalleſt is about the ſize of a hazle-nut. The

feathers on its wings and tail are black; but thoſe on its body, and under its wings, are of a greeniſh brown, with a fine red caſt or gloſs, which no ſilk or velvet can imitate. It has a ſmall creſt on its head, green at the bottom, and as it were gilded at the top; and which ſparkles in the ſun like a ſtar in the middle of its forehead. The bill is black, ſtraight, ſlender, and of the length of a ſmall pin.

As ſoon as the ſun is riſen, the humming-birds, of different kinds, are ſeen fluttering about the flowers, without ever lighting upon them. Their wings are in ſuch rapid motion, that it is impoſſible to diſcern their colours, except by their glittering. They are never ſtill, but continually in motion, viſiting flower after flower: they are furniſhed with a forky tongue, that enters the cup of the flower, and extracts its nectared tribute. Upon this alone they ſubſiſt. The rapid motion of their wings brings out an humming ſound, from whence they have their name.

The neſts of theſe birds are not leſs curious than the reſt: they are ſuſpended in the air, at the points of twigs of an orange, a pomegranate, or a citron-tree. The female is the architect, while the male goes in queſt of materials; ſuch as cotton, fine moſs, and the fibres of vegetables. Of theſe materials a neſt is compoſed, of about the ſize of a hen's egg cut in two, admirably contrived, and warmly lined with cotton. They lay two eggs at a time, about the ſize of ſmall peas, and as white as ſnow, with here and there a yellow ſpeck. The male and female ſit upon the neſt by turns; but the female takes to herſelf the greateſt ſhare. She ſeldom quits the neſt, except a few minutes in the morning and evening when the dew is upon the flowers. The time of incubation continues twelve days; at the end of which the young ones appear, much about the ſize of a blue-bottle fly.

Father Labat's companion, in the miſſion to America, found the neſt of a humming-bird, and took it in, at a time when the young ones were about fifteen or twenty days old; he placed them in a cage at his chamber window; but he was ſoon ſurpriſed to ſee the old ones, that came and fed their brood regularly every hour in the day. By theſe means they themſelves ſoon

grew

grew ſo tame, that they ſeldom quitted the chamber; but without any conſtraint, came to live with their young ones.

All four have frequently come to perch upon their maſter's hand, chirruping as if they had been at liberty. He fed them with a fine clear paſte, made of wine, biſcuit, and ſugar. They thruſt their tongues into this paſte, till they were ſatisfied, and then fluttered and chirruped about the room. I never beheld any thing more agreeable, continues he, than this lovely little family, that had taken poſſeſſion of my companion's chamber, and that flew out and in juſt as they thought proper; but were ever attentive to the voice of their maſter when he called them. In this manner they lived with him for above ſix months; but, at a time when he expected to ſee a new colony, he unfortunately forgot to tie up their cage to the ceiling at night, to preſerve them from the rats, and he found they were devoured in the morning.

Even vultures are in Egypt of ſingular ſervice. There are great flocks of them in the neighbourhood of Grand Cairo, which no perſon is permitted to deſtroy. The ſervice they render the inhabitants, is the devouring the carrion and filth of that great city, which might otherwiſe corrupt and putrify the air. They are commonly ſeen in company with the wild dogs of the country, tearing a carcaſe very deliberately together. This odd aſſociation produces no quarrels; the beaſts and birds live amicably, and nothing but harmony ſubſiſts between them.

The wonder is ſtill the greater, as both are extremely rapacious, and both lean and bony to a very great degree, having no great plenty, even of the wretched food on which they ſubſiſt.

In America, wherever the hunters go, who purſue beaſts for their ſkins, theſe birds purſue them. They ſtill keep hovering at a little diſtance; and when they ſee the beaſt flayed and abandoned, they call out to each other, pour down upon the carcaſe, and in an inſtant, pick its bones as clean as if they had been ſcraped by a knife.

Rooks keep together in pairs; and when the offices,

of courtſhip are over, prepare for making their neſts and laying. The old inhabitants of the place are already provided; the neſt which ſerved them for years before, with a little dreſſing will ſerve again; the difficulty of neſtling lies only upon the young ones who have no neſt. And not only the materials are wanting, but alſo the place in which to fix it. Every part of a tree will not do for this purpoſe, as ſome branches may not be ſufficiently forked; others may not be ſufficiently ſtrong; and others may be too much expoſed to the rockings of the wind.

The male and female upon this occaſion are, for ſome days, ſeen examining all the trees of the grove very attentively; and when they have fixed upon a branch fit for that purpoſe, they continue to ſit upon and obſerve it very ſeduloufly for two or three days longer.

The place being determined, they begin to gather the materials; ſuch as ſticks and fibrous roots, which they regularly diſpoſe in the moſt ſubſtantial manner. But here a new and unexpected obſtacle ariſes: it often happens that the young couple have made choice of a place too near the manſion of an older pair, who do not chuſe to be incommoded by neighbours. A quarrel therefore inſtantly enſues, in which the old ones are always victorious.

The young couple thus expelled, are obliged again to go through the fatigues of examining, and chuſing; and having taken care to keep their due diſtance, the neſt begins again. But they grow weary of bringing materials from diſtant places; and perceive that ſticks may be provided nearer home. Away they go, therefore, to pilfer as faſt as they can; and wherever they ſee a neſt unguarded, they rob it of the choiceſt ſticks of which it is compoſed. But theſe thefts never go unpuniſhed. Eight or ten rooks come, and ſettling upon the new neſt of the young couple at once, tear it in pieces in a moment.

At length, therefore, the young pair find the neceſſity of going more honeſtly to work. While one flies to fetch the materials, the other ſits upon the tree to guard it; and thus in the ſpace of three or four days, with a ſkirmiſh now and then between, the pair

have

have fitted up a commodious neſt, compoſed of ſticks without, and fibrous roots and long graſs within. From the inſtant the female begins to lay, all hoſtilities are at an end; not one of the whole grove, that a little before treated her ſo rudely, will now moleſt her; ſo that ſhe brings forth her brood with patient tranquillity. Such is the ſeverity with which even native rooks are treated by each other; but if a foreign rook ſhould attempt to make himſelf a denizen of their ſociety; the whole grove would at once be up in arms againſt him, and expel him without mercy.

In all its habits the magpie diſcovers a degree of inſtinct unuſual to other birds. Its neſt is not leſs remarkable for the manner in which it is compoſed, than for the place it is built in: either in the middle of ſome hawthorn buſh, or on the top of ſome high tree.

It is always difficult of acceſs; for the tree or buſh pitched upon, uſually grows in ſome thick hedge-row, fenced by brambles at the root.

When the place is choſen as inacceſſible as poſſible to men; the next care is to fence the neſt above from various enemies.

The kite, the crow, and the ſparrow-hawk, are to be guarded againſt; as their neſts have been ſometimes plundered by the magpie, ſo it may be, they will take an opportunity to retaliate. To prevent this, the magpie's neſt is built with ſurpriſing labour and ingenuity.

The body of the neſt is compoſed of hawthorn branches; the thorns ſticking outward, but well united together by their mutual inſertion. It is lined with fibrous roots, wool, and long graſs, and nicely plaiſtered round with mud and clay. The body of the neſt being thus made firm and commodious, the next work is to make the canopy which is to defend it above.

This is compoſed of the ſharpeſt thorns, ſo wove together, as to deny all entrance except at the door, which is juſt large enough to permit egreſs and regreſs to the owners. In this fortreſs the male and female hatch and bring up their brood with ſecurity, ſheltered from all attacks but thoſe of the climbing ſchool-boy, who often finds his torn and bloody hands too dear a price for the eggs or the young ones.

As the wood-pecker is obliged to make holes in trees to procure food, ſo is it alſo to make cavities ſtill larger to form its neſt and to lay in. This is performed, as uſual with the bill. He chuſes for this purpoſe, trees that are decayed, or wood that is ſoft, like beech, elm and poplar. In theſe, with very little trouble, it can make holes as exactly round as a mathematician could with compaſſes. One of theſe holes the bird generally chuſes for its own uſe, to neſtle, and bring up its young in: but as they are eaſily made, it is delicate in its choice, and often makes twenty, before one gives entire ſatisfaction.

In our climate wood-peckers are contented with a wainſcot habitation for their young; but in Guinea and Brazil, they take a very different method. A traveller who walks into the foreſts of theſe countries, among the firſt ſtrange objects, is ſtruck with the multitude of bird neſts hanging at the extremity of almoſt every branch. Many other kinds of birds build in this manner, but the chief of them are of the wood-pecker kind.

In cultivated countries a great part of the caution of the feathered tribe is to hide their neſts from the invaſion of man. But in the depths of thoſe remote and ſolitary foreſts, the little bird having nothing to apprehend from man, is careleſs how much the neſt is expoſed to general notice: ſatisfied if it be out of the reach of thoſe rapacious creatures that live by robbery, and ſurpriſe. If the monkey or the ſnake can be guarded againſt, the bird has no other enemies to fear: for this purpoſe, its neſt is built upon the depending points of the moſt outward branches of a tall tree. On one of thoſe immenſe trees, is ſeen the moſt various aſſemblage of creatures that can be imagined. The top is inhabited by monkies of ſome peculiar tribe, that drive off all others; lower down twine about the trunk numbers of ſnakes, waiting till ſome unwary animal comes within their reach, and at the edges of the tree hang theſe artificial neſts, inhabited by birds of the moſt delightful plumage.

The neſts are uſually formed in this manner: when the time of incubation approaches, they fly beautifully about, in queſt of a kind of moſs, called by the

 Engliſh,

Engliſh, old man's beard. It is a fibrous ſubſtance, not unlike hair, which bears being moulded into any form. This the little wood-pecker firſt glues by ſome viſcous ſubſtance, to the extreme branch of a tree; then building downward, a neſt is formed, that deſcends like a pouch, from the point of the branch: the hole to enter at, is on the ſide; and all the interior parts are lined with the finer parts of the ſame ſubſtance, which compoſe the whole.

Such is the general contrivance of theſe hanging neſts; made by ſome other birds, with ſtill ſuperior art. A little bird in the Philippine Iſlands, makes its neſt in ſuch a manner that there is no opening but from the bottom. At the bottom the bird enters, and goes up through a funnel, like a chimney, till it comes to the real door of the neſt, which lies on one ſide.

Some birds glue their neſts to the leaf of the banana-tree, which makes two ſides of their little habitation; while the other two are artificially compoſed by their own induſtry. But theſe and all of the kind, are built with the ſame precautions, to guard their young againſt the depredations of monkies and ſerpents. The neſt hangs there, before the ſpoilers, a tempting object, which they can only gaze upon, while the bird goes in and out without danger and moleſtation.

The bird of paradiſe appears to be as large as a pigeon, though in reality not much greater than a thruſh. The tail is about ſix inches long, the wings are large, compared with the bird's other dimenſions. The head, the throat and the neck are of a pale gold colour. The baſe of the bill is ſurrounded by black feathers, as alſo the ſide of the head and throat, as ſoft as velvet, and changeable like thoſe on the neck of a mallard. The hinder part of the head is of a ſhining green, mixed with gold. The body and wings are chiefly covered with brown, purple and gold feathers. The uppermoſt part of the tail-feathers are of a pale yellow, and thoſe under them white and longer than the former; for which reaſon the hinder part of the tail appears to be all white. But what chiefly excites curioſity, are, two long naked feathers, which ſpring from

from the upper part of the rump above the tail, and are uſually about three feet long. Theſe are bearded only at the beginning and the end, the whole ſhaft, for above two feet nine inches, being of a deep black, the feathered extremity of a changeable colour.

This bird is a native of the Molucca Iſlands. There, in the delightful and ſpicy woods, do theſe beautiful creatures fly in large flocks; ſo that the groves which produce the richeſt ſpices, produce the fineſt birds alſo. They are called by ſome, the ſwallows of Ternate, from their rapid flight, and from their being continually upon the wing, in purſuit of inſects, their uſual prey.

The American mock-bird, does not vie with the feathered inhabitants of that country in the beauty of his plumage. It is a plain bird about the ſize of a thruſh, of a white and grey colour, and a reddiſh bill. It is poſſeſſed not only of its own natural notes, which are muſical and ſolemn, but can aſſume the tone of every other animal in the wood, from the wolf to the raven. It ſeems even to ſport itſelf in leading them aſtray. It will at one time allure the leſſer birds with the call of their males, and terrify them when they come near with the ſcreams of the eagle. There is no bird in the foreſt, but it can mimic; and there is none that it has not at times deceived by its call. But it is fureſt to pleaſe, when it is moſt itſelf.

At thoſe times it frequents the houſes of the American planters; and ſitting all night on the chimney-top, pours forth the ſweeteſt and the moſt various notes of any bird whatever.

The crane, is above three feet from the tip of the beak to the tail, and four feet from the head to the toe. It is a tall, ſlender bird, with a long neck and long legs. The top of the head is covered with black briſtles, and the back of it is bald and red, which ſufficiently diſtinguiſhes this bird from the ſtork, to which it is very nearly allied in ſize and figure.

Cranes were formerly known in this iſland, and held in great eſtimation for the delicacy of their fleſh: there

was

was even a penalty upon ſuch as deſtroyed their eggs: but at preſent, they never go far out of their way.

Cultivation and populouſneſs go hand in hand; and though our fields may offer them a greater plenty, yet they find the venture greater than the enjoyment; and we are better off by their abſence than their company.

The crane ſpends the autumn in Europe; then flies off to ſome more ſouthern climate; returns to Europe in ſpring; croſſes up to the north in ſummer; viſits thoſe lakes that are never dry; and then comes down again to Italy in autumn.

In theſe journies it is amazing to conceive the heighths to which they aſcend. Their note is the loudeſt of all birds; and that is often heard in the clouds, when the bird itſelf is entirely unſeen. But though unſeen themſelves, they have the diſtinct viſion of every object below. They govern and direct their flight by their cries; and exhort each other to proceed or deſcend, when a fit opportunity offers.

Their loud, clangorous ſound is, when near, almoſt deafening: however, it is particularly ſerviceable to the animal itſelf, either during its migrations or ſtay: by it the flock is encouraged in their journies; and if while they are feeding, which is performed in profound ſilence, they are invaded on any ſide, the bird that firſt perceives it ſounds the alarm, and all are ſpeedily upon the wing.

The ſtork alſo is a bird of paſſage, and goes away toward winter to the ſouthern countries. It has a very long beak, and long, red legs. It feeds on ſerpents, frogs, and inſects. As it ſeeks for theſe in watry places, nature has provided it with long legs. And as it flies to the neſt with its prey, its bill is ſtrong and jagged, to hold faſt what it has taken. She likewiſe digs with her bill into the earth for ſnakes or adders, which ſhe carries to her young. Moſt of her feathers are white. She lays but four eggs, and ſits for thirty days.

But what renders this bird moſt remarkable is, its ſteady love to its parents. It never forſakes them when they are old, but tenderly feeds and defends them, as long as they live.

The

The following adventure of a tame ſtork ſome years ago in the Univerſity of Tubingen ſeems to ſhew a degree of underſtanding, which one would ſcarce expect in the brute creation. This bird lived quietly in the court-yard, till Count Victor Gravenitz, then a ſtudent there, ſhot at a ſtork's neſt, adjacent to the college, and probably wounded the ſtork then in it. This happened in autumn, when foreign ſtorks uſually leave Germany. The next ſpring a ſtork was obſerved on the roof of the college, which after a time came down to the upper gallery, the next day ſomething lower, and at laſt, by degrees quite into the court. The tame ſtork went to meet him with a ſoft cheerful note, when the other fell upon him with the utmoſt fury. The ſpectators drove him away; but he came again the next day, and during the whole ſummer, there were continual ſkirmiſhes between them. The ſpring following, inſtead of one ſtork, came four, and attacked him all at once. A ſurpriſing event followed. All the turkies, ducks and geeſe, that were brought up in the court ran together, and formed a kind of rampart round him, againſt ſo unequal a combat. This ſecured him for the preſent. But in the beginning of the third ſpring, about twenty ſtorks ſuddenly alighted in the court, and before the poor ſtork's life-guards could form themſelves, or the people come to his aſſiſtance, they left him dead on the ſpot; which none could impute to any thing but the ſhot fired by Count Victor at the ſtrange ſtork's neſt.

The pelican ſomewhat reſembles a ſwan. The body is as large, the neck nearly as long, the legs are ſhort, and the feet are black, broad and webbed in the ſame manner. It is alſo of a whitiſh colour, only the tips of ſome of his feathers are black. It is much in the waters. It has a moſt horrid voice, like that of a man grievouſly lamenting.

Its beak is above a foot in length, and the point is very ſharp. The upper part is formed as in other birds; but the lower is unlike every thing in nature. It is made of two long flat ribs, with a tough membrane connected to one and the other. This reaches

alſo

alſo to the throat, and is very broad and looſe, ſo that it can contain a vaſt quantity of proviſions.

Its eyes are very ſmall; there is a ſadneſs in its countenance; and its whole air is melancholy. They are torpid and inactive to the laſt degree, ſo that nothing can exceed their indolence, but their gluttony; it is only from hunger that they labour; otherwiſe they would continue in a fixed repoſe. When they have raiſed themſelves thirty or forty feet above the ſea, they turn their head with one eye downwards, and continue to fly in that poſture. As ſoon as they perceive a fiſh near the ſurface, they dart upon it with the ſwiftneſs of an arrow, ſeize it with unerring certainty, and ſtore it up in their pouch. They then riſe again, and continue hovering and fiſhing, with their head on one ſide as before.

This work they continue till their bag is full, and then fly to land to devour and digeſt it. This they are not long performing; for towards night they have another hungry call; and they again reluctantly go to labour. At night fiſhing is over, and they retire a little way from the ſhore; and though with the webbed feet and clumſy figure of a gooſe, they will be contented to perch no where but upon trees among the light and airy tenants of the foreſt. There they repoſe for the night; and often ſpend great part of the day, ſitting in diſmal ſolemnity, as it were half aſleep. Their attitude is, with the head reſting upon their breaſt. There they remain without motion till the calls of hunger break their repoſe.

The ſame indolence attends them, even in preparing for incubation, and defending their young. The female makes no preparation for the neſt, nor ſeems to chuſe any place to lay in; but drops her eggs on the bare ground to the number of five or ſix; and there continues to hatch them. Without any deſire of defending her eggs or her young, ſhe tamely ſits, and ſuffers them to be taken from under her.—Now and then ſhe juſt ventures to peck or to cry out when a perſon offers to beat her off. She feeds her young with fiſh macerated in her bag: and when they cry, flies off for a new ſupply.

They are but diſagreeable and uſeleſs domeſtics; their gluttony can ſcarcely be ſatisfied; their fleſh ſmells very rancid, and taſtes a thouſand times worſe than it ſmells. The native Americans kill vaſt numbers; not to eat, for they are not fit even for the banquet of a ſavage; but to convert their large bags into purſes and tobacco-pouches. They beſtow no ſmall pains in dreſſing it with ſalt and aſhes, rubbing it well with oil, and then forming it to their purpoſe. It thus becomes ſo ſoft and pliant, that the Spaniſh women ſometimes adorn it with gold and embroidery to make work-bags of.

Yet with all the hebetude of this bird, it is not entirely incapable of inſtruction. The emperor Maximilian had a tame pelican which lived for above eighty years, and always attended his army on the march.

The albatroſs is one of the largeſt and moſt formidable birds of Africa and America. It is as large as a gooſe, of a brown colour, and is one of the moſt fierce of the aquatic tribe, not only living upon fiſh, but alſo ſuch ſmall water-fowl as it can take by ſurpriſe. It preys, as all the gull-kind do, upon the wing; and chiefly purſues the flying-fiſh. Theſe are every moment riſing to eſcape from their purſuers of the deep, only to encounter equal dangers in the air. Juſt as they riſe, the dolphin is ſeen to dart after them, but generally in vain. The gull has more ſucceſs, and often takes them at their riſe, while the albatroſs purſues the gull, ſo that the whole horizon preſents but one living picture of rapacity and evaſion.

But though this bird be one of the tyrants of the deep, there are ſome aſſociations which even tyrants form, either by caprice, or neceſſity. The albatroſs has a peculiar affection for the penguin. They chuſe the ſame places for breeding; ſome diſtant, uninhabited iſland, where the ground ſlants to the ſea, as the penguin is not formed either for flying or climbing.—In ſuch places their neſts are ſeen together, as if they ſtood in need of mutual aſſiſtance. Our men upon Falkland iſlands, were often amazed at the union preſerved between thoſe birds. In that bleak and deſolate ſpot, where they no way dreaded the encroachments of men,

men, they ſeemed to make their abode as comfortable as they expected it to be laſting. They built with an amazing degree of uniformity; their neſts covering fields by thouſands, and reſembling a regular plantation. In the middle, on high, the albatroſs raiſed its neſt, built of heath, ſticks, and long graſs, about two feet above the ſurface; round this the penguins made their lower ſettlements, rather in holes in the ground, and moſt uſually eight penguins to one albatroſs.

Nothing is a ſtronger proof that the preſence of man, not only deſtroys the ſociety of meaner animals, but their inſtincts alſo. Theſe neſts are now totally deſtroyed; the ſociety is broke up, and the albatroſs and penguins have gone to breed upon more deſert ſhores, in greater ſecurity.

The ſwan is as delicate in its appetite, as elegant in its form. Its chief food is corn, bread, herbs growing in the water, and roots and ſeeds, which are found near the margin. It prepares a neſt in ſome retired part of the bank, and chiefly where there is an iſlet in the ſtream. This is compoſed of water-plants, long graſs, and ſticks; and the male and female aſſiſt in forming it with great aſſiduity. The ſwan lays ſeven or eight eggs, white, much larger than thoſe of a gooſe. It ſits near two months before its young are excluded, which are aſh-coloured for ſome months. It is dangerous to approach the old ones, when their little family is feeding round them. They ſoon take the alarm, and they ſometimes give a blow with their pinion, that breaks a man's leg or arm.

It is not till they are a twelvemonth old, that the young ſwans change their colour with their plumage. All the ſtages of this bird's approach to maturity are ſlow; and mark its longevity. A gooſe has been known to live a hundred years, and the ſwan is ſuppoſe to live ſtill longer.

The gooſe, in its domeſtic ſtate, exhibits a variety of colours. The wild gooſe always retains the ſame marks; the whole upper part is aſh-coloured; the breaſt and belly are of a dirty white; the bill is narrow at the baſe, and at the tip it is black. Theſe marks are ſeldom found in the tame; whoſe bill is entirely

tirely red, and whoſe legs are entirely brown. The wild gooſe is rather leſs than the tame; but both invariably retain a white ring round the tail, which ſhews that they are both deſcended from the ſame original.

The wild gooſe breeds in the northern parts of Europe; and in the beginning of winter, deſcends into more temperate regions. They are often ſeen flying at very great heights, in flocks from fifty to a hundred. Their cry is frequently heard, when they are at an imperceptible diſtance above us; and this ſeems handed from one to the other, as among hounds in the purſuit.

Upon their coming to the ground by day, they range themſelves in a line, and ſeem rather to deſcend for reſt than refreſhment. When they have ſat in this manner for an hour or two, one of them, with a loud, long note, ſounds a kind of charge, to which the reſt attend, and purſue their journey with renewed alacrity.

The wild gooſe ſeldom lays above eight eggs; the tame gooſe often above twenty. The female hatches her eggs with great aſſiduity; while the gander viſits her twice or thrice a day, and ſometimes drives her off to take her place, where he ſits with great ſtate and compoſure.

But beyond that of all animals is his pride when the young are excluded: he ſeems then to conſider himſelf as a champion; he purſues dogs and men that never attempt to moleſt him; and, though the moſt harmleſs thing alive, is then the moſt petulant and provoking. When, in this manner, he has purſued the calf or the maſtiff, to whoſe contempt alone he is indebted for ſafety, he returns to his female and her brood in triumph, clapping his wings, ſcreaming, and ſhowing all the marks of conſcious ſuperiority.

The Soland-gooſe, ſomewhat leſs than a land-gooſe, is white: only the tips of its wings are black, and the top of the head yellow. The bill is long, and ſo ſharp-pointed, that it pierces an inch deep into a board, when they ſtoop at fiſh which are laid thereon. This is one

way

way of catching them. When they ſleep, they put their head under their wings: but one keeps watch.—If that be ſurpriſed by the fowler, which frequently happens, all the reſt are eaſily caught by the neck one after another. But if the ſentinel cries and gives them warning, the whole flock eſcapes. When they fiſh for herrings, which come in ſhoals, they fly near ſixty yards high, and ſtoop perpendicularly. But when they aim at a ſingle fiſh, they deſcend aſlant.

There is always one tribe among them which is barren: theſe keep together, and never mix with them that build and hatch. (Is it not probable, that theſe are the males, like the drones among the bees?) The Soland geeſe come to the Weſtern Iſles in Scotland in March, taking the advantage of a ſouth-weſt wind.—They ſend a few before them who make a tour round the iſles, and then return to their company. In a few days after, the whole flock comes together, and ſtays till September. All this time they are daily making up their neſts in the ſhelves of high rocks. They fiſh, hatch and make their neſts by turns. In order to this they amaſs together, not only heaps of graſs, but whatever elſe they find floating, on the water. In a neſt on St. Kilda, was found a ſoldier's red coat, and ſome Molucca beans in another.

They are thought the ſharpeſt ſighted of all ſea-fowls. They have a large gorget, ſomewhat like a pelican, in which one of them will preſerve five or ſix herrings entire, and carry them to her neſt, where they empty them out, for food to their young. Nay, they have been obſerved to go a fiſhing, to ſome iſles which are thirty leagues diſtant, and bring the fiſh in their gorget all that way.

In the iſle of Rona, (one of the Scotch Weſtern iſles) there are a couple of eagles, which the natives ſay, not only drive away their young as ſoon as they are able to fly; but keep poſſeſſion of the iſland, not ſuffering any of their kind to live their but themſelves.

There are alſo a couple of ravens in this iſland, which beat away all ravenous fowls. And when their

their own young is able to fly, they beat them away likewiſe.

That which in Iceland they call the down-bird, is very remarkable. It is a ſpecies of duck, but covered with fine, ſoft, downy feathers. The drake is full as large as a gooſe, but the duck conſiderably ſmaller.—They abound all over Iceland, but particularly the weſtern part, on account of the iſlands off the coaſt, where chiefly they build their neſts. They build them with the down they pull from their breaſt. They lay four green eggs, as large as a gooſe's. The inhabitants then take away both the eggs and the neſt. The ducks go to work again, pull more down from their breaſts, and lay four eggs more, which are again taken away by the inhabitants. This does not however diſcourage the duck. She builds a third neſt, and lays four more eggs: but the drake is now obliged to ſupply the down, the duck having none left. They now let her hatch her young: for if they diſturb her a third time, ſhe builds no more that year, nor ever returns to the ſame place. When the young have left the neſt, they take it a third time, and ſo have two ſets of eggs, and three parcels of down from the ſame neſt.

The bat ſeems a medium between bird and beaſt.—But it comes nearer to the latter. They lay themſelves up and ſleep for the winter-months, in the dryeſt parts of caves. There fixing their talons in the roof, they cover their bodies with their wings, and hang perpendicularly in great numbers, but ſo as not to touch each other.

Who can account for another matter of fact which is particularly obſerved on the Weſtern Iſlands? The Weſtern Ocean throws up on their ſhores, great quantities of weather-beaten timber, on which hang multitudes of little ſhells, faſtened to one another, much as muſcle-ſhells are. In every one of theſe ſhells is a perfect fowl: the little bill is like that of a gooſe; the eye marked; the head, neck, breaſt, wings, tail and feet formed. The feathers are perfectly ſhaped, and of a blackiſh colour, and the feet like thoſe of other water-

water-fowl: but we cannot hear of any perſon that ever ſaw any of them alive.

Now as bats are a kind of medium between beaſts and birds, are not barnacles a kind of medium between birds and fiſhes?

I will conclude this account of birds, with one that ſeems to unite in itſelf ſomewhat of every claſs preceding. It is at once poſſeſſed of appetites for prey like the rapacious kinds, and an attachment to water like the birds of that element. It exhibits in its form the beautiful plumage of the peacock, the ſhadings of the humming-bird, the bill of the crane, and the ſhort legs of the ſwallow. The bird I mean is the king-fiſher. It is not much larger than a ſwallow; its ſhape is clumſy; the legs very ſmall, and the bill very long; it is two inches from the baſe to the tip; but the colours of this bird atone for its inelegant form.—The crown of the head and the edges of the wings are of a deep blackiſh green, ſpotted with bright azure; the back and tail are of the moſt reſplendent azure; the whole under-ſide of the body is orange-coloured: a broad mark of the ſame paſſes from the bill beyond the eyes; beyond that is a large white ſpot; the tail is ſhort, and conſiſts of twelve feathers of a rich, deep blue; the feet are of a reddiſh yellow.

From the diminutive ſize, and the beautiful colours of this bird, no perſon would be led to ſuppoſe it ſo rapacious an animal. It is ever on the wing, and feeds on fiſh, which it takes in ſurpriſing quantities, balancing itſelf at a certain diſtance above the water for a conſiderable ſpace, then darting down and ſeizing the fiſh with inevitable certainty.

The king-fiſher, with which we are acquainted, has none of thoſe ſuppoſed powers of allaying the ſtorm, or building upon the waves. It is contented to make its neſts on banks of rivers, in ſuch ſituations as not to be affected by the riſing of the ſtream. When it has found a place for its purpoſe, it hollows out with its bill a hole about a yard deep. Or if it find the de-

ſerted

ferted hole of a rat, it takes quiet poſſeſſion. This hole it enlarges at the bottom, and lining it with the down of the willow, lays its eggs there without any further preparation.

The female begins to lay early in the ſeaſon, and excludes her firſt brood about the beginning of April.—The male brings her large proviſions of fiſh, while ſhe is thus employed; and ſhe, contrary to moſt other birds, is found fat at the ſeaſon of hatching.

9. I have now only to add a few reflections.

And, 1. That birds ſhould all lay eggs, and not bring forth live young, is a clear argument of Divine Providence, deſigning their preſervation thereby.—For if they had been viviparous, had they brought any number at a time, the burden of their womb muſt have been ſo great and heavy, that their wings would have failed, and they become an eaſy prey to their enemies. And had they borne but one at a time, they would have been bearing all the year.

2. Since it would have been many ways inconvenient to birds to give ſuck; and yet inconvenient, if not deſtructive to the new-born chick, to paſs ſuddenly from liquid to hard food, before the ſtomach was ſtrengthened and able to digeſt it, and before the bird was accuſtomed to uſe its bill; and gather it up, which it does at firſt very ſlowly and imperfectly: therefore nature has provided in every egg a large yolk, which ſerves the chicken a conſiderable time inſtead of milk. Mean time it feeds by the mouth a little at a time, and that more and more, till the ſtomach is ſtrengthened to digeſt it.

3. Birds that feed their young in the neſt, though they bring but one morſel at a time, and have perhaps ſeven or eight, which all at once, with equal greedineſs, hold up their heads, and gape for it; yet never miſtake, never omit one, but feed them all by turns.

4. Though

4. Though birds cannot number, yet they are able to diſtinguiſh many from few. And when they have laid as many eggs as they can cover, they give over, and begin to ſit. Yet they are not determined to ſuch a number: they can go on and lay more at their pleaſure. Hens, for inſtance, if you let their eggs alone, lay fourteen or fifteen, and give over. But if you withdraw their eggs daily, they will go on, to lay five times that number. This holds not only in domeſtic birds, but alſo in the wild. A ſwallow, when her eggs were withdrawn daily, proceeded to lay nineteen.

5. It is remarkable, that birds, and ſuch other oviparous creatures as are long-lived, have eggs enough conceived in them at firſt, to ſerve laying for many years, allowing ſuch a proportion for every year, as will ſuffice for one or two incubations.—Whereas inſects, which are to breed but once, lay all their eggs at once, be they ever ſo many.

6. How exceeding ſpeedy is the growth of birds that are fed by the old ones in the neſt! Moſt of them come to near the full bigneſs, within the ſhort term of a fortnight: an admirable proviſion, that they may not lie long in that helpleſs condition, expoſed to the ravine of any vermin, and utterly unable to ſhift for themſelves.

7. What amazing care do the parents take, for the hatching and rearing of their young? Firſt, they ſeek out a ſecret and quiet place, where they may be undiſturbed in their incubation. Then they make their neſts, every one after his kind, that their eggs and young may be ſoft and warm: and thoſe ſo elegant and artificial, as no art of man can imitate.

After they have laid their eggs, how diligently do they ſit upon them, ſcarce giving themſelves time to go off, to get them meat? When the young are hatched, how diligently do they brood over them, leſt the cold ſhould hurt them? All the while labouring hard to get them food, and almoſt ſtarving themſelves, leſt they ſhould want. Moreover, with what courage are they

they inſpired, ſo as to venture their own lives in defence of them? The moſt timorous, as hens and geeſe, daring then even to fly in the face of a man. And all theſe pains are beſtowed upon thoſe that will render them no thanks for it! And they are beſtowed juſt ſo long as is neceſſary. For when the young is able to ſhift for itſelf, the old retains no ſuch affection for it, but will beat it indifferently with others.

8. It is another proof of a ſuperintending Providence, that all animals are produced at the moſt convenient time of the year, juſt when there is food and entertainment ready for them. So lambs, kids, and many other living creatures, are brought into the world in the ſpring, when tender graſs and nutritive plants are provided for their food. The like may be obſerved concerning ſilk-worms, whoſe eggs are hatched juſt when the leaves of the mulberry-tree appear; the aliment being ſoft and tender, while the worms themſelves are ſo, and growing more ſtrong and ſubſtantial, as the inſects increaſe in bulk and vigour.

9. A ſtill farther proof hereof we have in the various inſtincts of animals, directed to ends which they know not, as, 1. All creatures know how to defend themſelves, and offend their enemies. All know what their natural weapons are, and how to make uſe of them. A boar knows the uſe of his tuſks, a horſe of his hoofs, a cock of his ſpurs, a bee of her ſting.—Yea a calf will make a puſh with his head, even before any horns appear. 2. Thoſe creatures which have not ſtrength to fight, are uſually ſwift of foot or wing, and are naturally inclined to make uſe of that ſwiftneſs, and ſave themſelves by flight. 3. Every creature knows and ſhuns its natural enemy, as a lamb does the wolf, and partridge or poultry, birds of prey. And they make uſe of a peculiar note, to warn their young of their approach, who thereupon immediately run to ſhelter. 4. As ſoon as ever it is brought forth, every animal knows its food. Such as are nouriſhed with milk, immediately find their way to the paps, and ſuck: whereas thoſe which are deſigned for other nouriſhment, never make any ſuch attempt. 5. Birds

that

thatare fin-toed, or whole-footed, are naturally directed to go into the water. So ducklings, though hatched and led by a hen, if ſhe bring them to the brink of a river or pond, preſently leave her and go in, though they never ſaw any ſuch thing before; and though the hen clucks and calls, and does all ſhe can to keep them out. 6. Birds of the ſame kinds make their neſts of the ſame materials, laid in the ſame order, and exactly of the ſame figure, ſo that by the ſight of the neſt one may certainly know what bird it belongs to. And this, though living in diſtant countries, and though they never ſaw any neſt made; that is, although they were taken out of the neſt, and brought up by hand. Nor were any of the ſame kind ever known to make a different neſt, either for matter or faſhion: unleſs where the uſual matter was not to be had: in that caſe, ſome birds uſe what they can get.

I would add a little farther improvement of ſome particulars mentioned before.

What maſter has taught birds, that they have any need of neſts? Who has warned them, to prepare them in time, and not to ſuffer themſelves to be prevented by neceſſity? Who hath ſhewn them how to build? What mathematician has given the figure of them? What architect has taught them to chuſe a firm place, and to build a ſolid foundation? What tender mother has adviſed them to cover the bottom with a ſoft and delicate ſubſtance, ſuch as cotton or down, and when theſe fail, who has ſuggeſted to them that ingenious charity, to pluck off as many feathers from their own breaſt, as will prepare a ſoft cradle for their young?

Again. What wiſdom has pointed out to each kind a peculiar manner of building? Who has commanded the ſwallow, to inſtance in one, to draw near to man, and make choice of his houſe for the building her neſt, within his view, without fear of his knowing it, but ſeeming rather to invite him to a conſideration of her labour? Nor does ſhe build like other birds, with bits

of

of ſticks, and ſtubble, but employs cement and mortar: and that in ſo firm a manner, that it requires ſome pains to demoliſh her work. And yet in all this, it has no other inſtrument to make uſe of but a little beak.

Yet again. Who has made the birds comprehend that they muſt hatch their eggs by ſitting upon them. That this neceſſity is indiſpenſible: that the father and mother could not leave them at the ſame time; and that if one went abroad to ſeek for food, the other muſt wait till it returns? Who has told them the preciſe number of days this painful diligence is to coſt? Who has taught them to aſſiſt the young in coming out of the egg, by breaking the ſhell for them? Yea, and adverti ſed them of the very moment, before which they never come?

Who has taught ſeveral of the birds that marvellous induſtry, of retaining food and water in their gullet, without ſwallowing either, and preſerving them for their young, to whom this preparation ſerves inſtead of milk?

Is it for the birds, O Lord, who have no knowledge thereof, that thou haſt joined together ſo many miracles? Is it for the men who give no attention to them? Is it for thoſe who admire them, without thinking of Thee? Rather is it not thy deſign, by all theſe wonders to call us to thyſelf? To make us ſenſible of thy wiſdom, and fill us with confidence in thy bounty, who watcheſt ſo carefully over thoſe inconſiderable creatures, two of which "are ſold for a farthing?"

But paſs we from the induſtry of birds, to hearken for a moment to their muſic: the firſt ſong of thankſgiving which was offered on earth before man was formed. All their ſounds are different, but all harmonious, and altogether compoſe a choir which we cannot imitate. One voice however more ſtrong and melodious I diſtinguiſh above the reſt. On inquiry I find it comes from a very ſmall bird. This leads me to conſider the reſt of the ſinging birds. They likewiſe are all ſmall: the great ones having a harſh and diſagreeable

diſagreeable voice. Such an amends is made to theſe weak, little creatures, for their defect of ſtrength?

Some of theſe little birds are extremely beautiful, nor can any thing be more rich or variegated than their feathers. But it muſt be owned, that all ornament muſt give place to the finery of the peacock; upon which God has plentifully beſtowed all the riches which ſet off the reſt, and laviſhed upon it with gold and azure, all the ſhades of every other colour. This bird ſeems ſenſible of its advantage, and looks as if it deſigned to diſplay all its beauties to our eyes, when it ſtalks along, and expands that ſplendid circumference, which ſets them all in open view.

But this pompous bird has of all others that are kept tame, the moſt diſagreeable cry, and is a proof, that there may be a ſhining outſide, when there is little ſubſtance within.

In examining the feathers of the reſt, I find one more circumſtance very obſervable. That feathers of ſwans and other water fowl, are proof againſt the water. And accordingly they continue dry, though the creature ſwims or dives ever ſo long. And yet neither our eyes, nor all our art can diſcover, wherein they differ from others.

I know not how to conclude this chapter, without adding a few more reflections.

All the univerſe is repleniſhed with life; and every part of it, with its proper animals. But would one expect to ſee them in the air? Nothing ſeems more natural to our eyes; but nothing is more aſtoniſhing to our reaſon. The fact is certain, and yet might ſeem to be altogether impoſſible. A bird in flight, is a maſs raiſed aloft, in ſpite of the gravity of the air, and the tendency of all bodies to the earth. This maſs is raiſed not by any foreign force, but by a movement ſuited to the purpoſe of the creature, and which ſuſtains it in the air, for a conſiderable time, with a peaceful vigour.

Again.

Again. In the whole kingdom of birds, none have more than two wings, and yet they all fly in a different manner. Some launch away by repeated ſprings; others glide through the air with an even motion. Theſe always ſkim over the earth; thoſe ſoar up to the clouds. Some know how to diverſify their flight, by a ſtrait, oblique, or circular motion: to ſuſpend their bodies, and continue motionleſs in an element lighter than themſelves: after this, to ſtart into a horizontal motion, and then dart either to the right or left, wheel into a contrary tract, remount, and then precipitate themſelves like a deſcending ſtone: in a word, they tranſport themſelves, without oppoſition or hazard, wherever their neceſſities or pleaſures call them.

The ſtructure of their neſts, the care with which they attend their eggs, the mechaniſm of the egg itſelf, and the birth and education of their young, are equally aſtoniſhing. See the perfect ſimilitude that appears in all the neſts of birds of the ſame ſpecies, the conſtant difference between the neſts of one ſpecies and another! Together with the neatneſs and precaution which all of them obſerve. One ſpecies builds its neſt on the top of trees; another on the ground, under a canopy of graſs; but always with a ſhelter, either of herbs, or a branch, or a double roof of leaves, down which the rain ſlides, without entering the opening, which lies concealed below. The outward part of the neſt is made of ſolid materials, thorns, reeds, clay, or compact moſs; the inner of ſofter materials cloſely interwoven, ſo as to keep out both winds and inſects. But each ſpecies has a peculiar taſte. When the building is completed ſome hang the inſide with a tapeſtry of feathers, or quilt it with wool or ſilk.

How admirably does this diſplay the wiſdom of Him who furniſhed man with reaſon, which extends to every thing around him, and inſpired animals with an imitation of it, limited indeed to a few points, but admirable in that limitation? For who informed the bird, that ſhe ſhould lay eggs, and want a neſt to lodge and nouriſh them with genial heat? That this heat would not be concentered round the eggs, if the neſt were too large?

large? and that were it ſmaller, it would not be capable of containing all the young? Who has taught her not to miſ-calculate the time, or lay her eggs before ſhe has completed her neſt?

The ſame wiſdom will more fully appear, if we obſerve what the egg contains, with the manner how the young is there formed, and how it iſſues from its confinement.

The yolk lies in the heart of the egg, incloſed in the firſt membrane, which is ſurrounded by the ſecond. Near the centre of the egg are the ligaments that ſuſtain the yolk, which is contained in a peculiar membrane. A ſecond membrane incloſes the firſt white; a third and fourth encompaſſes the whole. The ſhell is formed laſt of all, out of the ſalts evacuated from all the humours of the body, which the heat gradually fixes and conſolidates, to ſerve a double purpoſe, firſt that it may be excluded without cruſhing the contents; ſecondly to defend their young, till it is thoroughly formed, and ready to forſake the egg.

Under the membrane which ſurrounds the yolk, is a white ſpeck, which is the ſeed of the chick, in miniature. If the ſmalleſt portion of the vital ſpirit be infuſed into it from the male, by a proceſs of which we have no idea, in the inſtant the chick receives life, and the whole ſubſtance is in motion. If it is not infuſed, the egg may indeed be laid, but it never comes to a living creature.

The pulſation of the heart bears ſome analogy to the pendulum of a clock, from whoſe vibrations the whole machine derives all its motions. The moment the heart begins to beat, the animal is alive, and receives by the umbilic duct, the nouriſhment which it tranſmits to the other veſſels, whoſe branches diſtribute it to the whole body. All thoſe little canals, which were flat before, are now ſwelled and enlarged. The whole ſubſtance imbibes a proper aliment, and the chick begins to grow.

In this ſituation of the ſpeck out of which it is formed, one circumſtance is highly remarkable. This minute particle which is lodged on the film that in-

cludes

cludes the yolk is always near the centre of the egg, and toward the body of the dam, in order to be impregnated with a neceſſary warmth But in how admirable a manner is this effected? The yolk is ſuſtained by two ligaments, which faſten it on each ſide to the common membrane, that is glued on the ſhell. A line drawn from one ligament to the other, would not paſs through the middle of the yolk, but above the centre, and cut the yolk in two unequal parts, ſo that the ſmaller part which contains the ſeed, is of neceſſity raiſed towards the belly of birds that ſit: the other part as neceſſarily ſubſides, ſo that let the egg turn as it will, the young receives no hurt, but ſtill enjoys a warmth that puts all about it in motion. So it feeds at eaſe, firſt on the white, which is more thin and delicate, and afterwards on the yolk, which affords more ſubſtantial nouriſhment. When his bill is hardened, and he grows uneaſy at his confinement, he pecks and breaks the ſhell, and iſſues out fully repleniſhed with the yolk, which nouriſhes him a little longer, till he is ſtrong enough to raiſe himſelf upon his feet, and can march about to look for proviſions.

CHAP. III.

Of FISHES.

1. *The Number of Fiſhes.*
2. *Their Covering.*
3. *Their Brain.*
4. *Organs of Senſe:*
5. *Gills, or Lungs:*
6. *Heart:*
7. *Air-Bladder:*
8. *Stomach;*
9. *Fins:*
10. *Experiments on Fiſh.*
11. *Of Shell-Fiſh.*
12. *Of the Generation of Fiſhes.*
13. *Of ſome particular Sorts of Fiſhes.*
14. *General Reflections.*

THE ocean is the great receptacle of fiſhes. It has been thought by ſome, that all fiſhes are naturally

naturally of the ſalt element, and that they have mounted up into freſh water, by ſome accidental migrations. A few ſtill ſwim up rivers to depoſit their ſpawn: but the great body of fiſhes, of which the ſize is enormous, and the ſhoals endleſs, keep to the ſea, and would expire in freſh water. In that extenſive and undiſcovered abode, millions reſide, whoſe manners are a ſecret to us, and whoſe very form is unknown. The curioſity of mankind, indeed, has drawn ſome from their depths, and his wants many more. With the figure of theſe at leaſt he is acquainted: but for their purſuits, ſocieties, antipathies, pleaſures, times of geſtation, and manner of bringing forth, theſe all are hidden in the turbulent element that protects them.

1. The number of fiſh to which we have given names, and of the figure, at leaſt, of which we know ſomething, are above four hundred. Thus to appearance the hiſtory of fiſh is tolerably copious; but when we come to examine, it will be found the greateſt part of theſe we know very little of.

2. As moſt animals that live upon land have a covering to keep off the injuries of the weather, ſo all that live in the water, are covered with a ſlimy, glutinous matter, that, like a ſheath, defends their bodies from the ſurrounding fluid. This ſubſtance, ſecreted from the pores of the animal's body, ſerves not only to defend, but to aſſiſt the fiſh's eaſy progreſs through the water. Beneath this, in many kinds, is found a ſtrong covering of ſcales, that, like a coat of mail, defends it ſtill more powerfully; and under that, before we come to the muſcular parts of the body, an oily ſubſtance, which ſupplies the requiſite warmth and vigour.

3. It is obſervable in all, that though their heads are much larger in proportion to their bodies, yet their brain is conſiderably leſs than that of other animals. It conſiſts of only two ſmall ventricles, placed in the fore-part of the head.

4. Their organs of ſenſe do not much differ from thoſe of other animals. But in their eyes this is peculiar, that they are quite ſpherical, and that the optic nerves, in coming from the brain, croſs each other: whereas in other animals they incline a little to each other, but do not meet. A protuberant eye would have been inconvenient for fiſhes, by hindering their motion in ſo denſe a medium. And their continually bruſhing through the water, would have been apt to wear their eyes. Therefore their cornea is flat. But to make amends for this, and for the refraction of water, different from that of air, the wiſe Creator has made their cryſtalline ſpherical, which in other animals is more flat. It was formerly believed, they did not hear at all. But from later experiments, there is reaſon to believe, that ſeveral ſpecies of them do hear, though but in a low degree. Over the two holes in their head which ſerve for ſmelling, a fine membrane is ſpread, by which means they can open and ſhut them at pleaſure; a contrivance highly neceſſary for creatures that live in the water.

The ſenſe of ſmelling which in beaſts is ſo exquiſite, and among birds is not wholly unknown, ſeems given to fiſhes in a very moderate proportion. It is true, that all fiſhes have one or more noſtrils, and even thoſe that have not the holes perceptible without, yet have the proper formation of the bones for ſmelling within. But as air is the only medium we know, for the diſtribution of odours, it cannot be ſuppoſed that theſe animals reſiding in water, can be poſſeſſed of any power of being affected by them. If they have any perception of ſmells, it muſt be in the ſame manner as we diſtinguiſh by our taſte; and it is probable, the olfactory membrane in fiſhes, ſerve them inſtead of a diſtinguiſhing palate: by this they judge of ſubſtances, that firſt tincturing the water with their vapours, are thus ſent to the noſtrils of the fiſh, and no doubt produce ſome kind of ſenſation. This moſt probably muſt be the uſe of that organ in thoſe animals; as otherwiſe there would be the inſtrument of a ſenſe provided for them, without any power in them of enjoyment.

Hearing

Hearing in fiſhes is found ſtill more imperfect, if it be found at all. Certain it is, that anatomiſts have not been able to diſcover, except in the whale-kind, the ſmalleſt traces of an organ of hearing, either within or without the head. Indeed, of what advantage would this ſenſe be to animals that are incapable of making themſelves heard? They have no voice to communicate with each other, and conſequently have no need of an organ for hearing.

Seeing ſeems to be the ſenſe which fiſhes are poſſeſſed of in the greateſt degree. And yet even this is obſcure, if we compare it to that of other animals. The eye, in almoſt all fiſh, is covered with the ſame tranſparent ſkin that covers the reſt of the head: and which probably ſerves to defend it from the water, as they are without eye-lids. The globe of the eye is depreſſed before, and is furniſhed behind with a muſcle, which ſerves to lengthen or flatten it, according to the neceſſities of the animal. The cryſtalline humour, which in beaſts is flat, and of the ſhape of a button mould, in fiſhes is as round as a pea; or ſometimes oblong, like an egg.

From all this, it appears, that fiſhes are extremely near-ſighted; and that, even in the water, they can ſee objects only at a very ſmall diſtance.

Thus nature ſeems to have fitted theſe animals with appetites and powers of an inferior kind; and formed them for a ſort of paſſive exiſtence in the obſcure and heavy element to which they are conſigned: to preſerve their own exiſtence, and to continue it to their poſterity, fill up the whole circle of their purſuits and enjoyments.

5. Some fiſhes have lungs. But in the greater part the place of them is ſupplied by gills. As we take in and throw out the air by our lungs, ſo they take in the air, mixt with the water, by their mouth, and throw it out by their gills.

There is always much air encloſed in water. This the gills ſeparate from it, and preſent to the blood, as

it is preſented in the lungs of other animals. Each gill contains a great number of bony laminæ, conſiſting of an infinity of bony fibres, that ſuſtain the innumerable ramifications of the veins and arteries, which preſent the blood extremely ſub-divided, and as it were, each globule by itſelf to the water: between the laminæ, through the whole contexture of the gills, are an infinity of very narrow paſſages, which receive and divide the water taken in by the mouth, into minute particles. Then the air, its priſon-doors being in ſome meaſure opened, eſcapes and joins the blood of all the little arteries.

The gills have an alternate motion of dilation and compreſſion. When they dilate, the water is taken in; when they contract, it is driven out. It ſeems that in the inſtant of contraction, the air expreſt from the water is forced into the blood-veſſels. It is the ſame, as to our lungs. The air enters them at the time of inſpiration, but is received into the blood at the time of expiration only. So that the water which is taken in by the mouth of fiſhes, when ſtript of its air, is carried off by the gills. Mean time the air which is thus gained is diſtributed firſt to thoſe fine ramifications of the arteries, which are expanded upon the gill throughout, and then to the veins inoſculated therewith. And fiſhes can no more live without a conſtant ſupply of this, than land animals can.

The gills in all fiſhes are eight, four on each ſide. The lower gill is always ſmaller than the reſt. The other three on each ſide are gradually larger to the top one, which is always the largeſt. Each of theſe is formed of a bony ſubſtance, bent into the ſhape either of a ſemicircle or a bow. On the convex ſide of this, there is a ſort of plumes or leaves, each of which conſiſts of a double row of bony lamella, formed like ſo many ſickles, and fixed to the convex ſide of the bow by means of the membrane wherewith it is covered.

Theſe lamella have one part convex, and the other concave. The concave part of each lamella is applied to the convex part of the next oppoſite lamella. Every lamella is inveſted with a fine membrane, which receives the ramifications of the blood-veſſels. Every gill has an artery, a vein, and a nerve. The gills receive

ceive the blood which is thrown from the heart into the aorta, and derive it to the utmoſt parts of the lamella, from whence it returns by veins which diſtribute it throughout the body.

6. In moſt fiſhes the heart is like that in other animals. But in ſome it has only one ventricle? which neceſſarily occaſions a difference in the manner wherein the blood circulates. In ſome alſo the blood is not red, but clear and tranſparent. In others, eſpecially ſhell-fiſh, beſides the arteries and veins, there are open tubes, which convey the water to the fartheſt part of them: probaby that they may find no want of water, when they continue ſome time on ſhore.

7. The air-bladder is deſcribed as a bag filled with air, ſometimes compoſed of one, ſometimes of two, and ſometimes of three diviſions, ſituated towards the back of the fiſh, and opening into the maw or the gullet. It is commonly ſuppoſed, by its ſwelling at the will of the animal, to increaſe the ſurface of the fiſh's body, and ſo to enable it to riſe to the top of the water, and keep there at pleaſure. On the contrary, when the fiſh wants to deſcend, it is ſuppoſed to empty this bladder of its air, and ſo ſink to the bottom.

But many fiſhes have an air-bladder, that continually crawl at the bottom; ſuch as the eel and the flounder: and many more are entirely without it, that ſwim in every depth; ſuch as the anchovy and the freſh-water gudgeon. Indeed, the number of fiſhes that want this organ is alone a ſufficient proof that it is not neceſſary for the purpoſes of ſwimming; and the ventral fins, which in all fiſhes lie flat upon the water, are fully ſufficient to keep them at all depths.

8. The ſtomach is in general, placed next the mouth, and though not ſenſibly hot, is endued with a ſurpriſing faculty of digeſtion. Its digeſtive power ſeems in ſome meaſure to increaſe with the quantity of food it is ſupplied with; a ſingle pike having been known to devour a hundred roaches in three days. Its faculties alſo are as extraordinary, for it digeſts not only ſoft fiſh, but prawns, crabs and lobſters, ſhells

and

and all. Theſe the cod or the ſturgeon will not only devour, but diſſolve, though their ſhells are ſo much harder than the ſides of the ſtomach which contains them. This amazing faculty in the cold ſtomach of fiſhes has juſtly excited the curioſity of philoſophers; and has effectually overturned the ſyſtem of thoſe who ſuppoſe the heat of the ſtomach is alone a ſufficient inſtrument for digeſtion. The truth ſeems to be, that there is a power of animal aſſimulation lodged in the ſtomach of all creatures, which we can neither deſcribe nor define, converting the ſubſtances they ſwallow into a fluid, fitted for their own peculiar ſupport. This is done neither by trituration, nor by warmth, nor by motion, nor by a diſſolving fluid; but by ſome principle yet unknown, which acts in a different manner from all kinds of artificial maceration.

Yet though fiſh are thus hungry, and for ever prowling, no animals can ſuffer the want of food for ſo long a time. The gold and ſilver fiſh which we keep in vaſes, ſeem never to want any nouriſhment at all; whether it be that they feed on the water-inſects, too minute for our obſervation, or that water alone is a ſufficient ſupply. Even the pike, the moſt voracious of fiſhes, will live in a pond where there is none but himſelf, and what is more extraordinary, will be often found to thrive there.

Air however is ſo neceſſary to all fiſh, that they can live but a few minutes without it: yet nothing is more difficult to be accounted for, than the manner in which they obtain this neceſſary ſupply. Thoſe who have ſeen a fiſh in the water, muſt remember the motion of its lips and its gills, or at leaſt of the bones on each ſide that cover them. This motion in the animal is without doubt, analogous to our breathing, but it is not air, but water, that the fiſh actually takes in and throws out through the gills at every motion.

The manner of its breathing ſeems to be this. The fiſh firſt takes a quantity of water by the mouth, which is driven to the gills, theſe cloſe and keep the water ſo ſwallowed from returning by the mouth, while the bony covering of the gills prevents it from going through them, until the animal has drawn the proper quantity of air from the body of water thus imprisoned:

priſoned: then the bony covers open and give it a free paſſage; by which means alſo the gills again are opened, and admit a freſh quantity of water. Should the fiſh be prevented from the free play of its gills, or ſhould the bony covers be kept from moving, by a ſtring tied round them, the animal would ſoon fall into convulſions, and die in a few minutes.

9. The chief inſtrument in a fiſh's motion are the fins, which in ſome are much more numerous than in others. A fiſh completely fitted for ſailing is furniſhed with two pair; alſo three ſingle fins, two above and one below. Thus equipped it migrates with the utmoſt rapidity, and takes voyages of a thouſand leagues in a ſeaſon. But ſuch fiſh as have the greateſt number of fins have not always the ſwifteſt motion. The ſhark is one of the ſwifteſt ſwimmers, yet it wants the ventral fins; the haddock does not move ſo ſwift, though it has them.

The fins not only aſſiſt the animal in progreſſion, but in riſing or ſinking, in turning, or even leaping out of the water. To anſwer theſe purpoſes, the pectoral fins ſerve like oars, to puſh the animal forward. They are placed behind the opening of the gills; they are generally large and ſtrong, and anſwer the ſame purpoſes to the fiſh as wings do to a bird. Thoſe alſo balance the fiſh's head, when it is too large for the body, and keep it from tumbling prone to the bottom, as is ſeen in large headed fiſhes, when the pectoral fins are cut off. Next theſe are the ventral fins, placed under the belly. Theſe are always ſeen to lie flat on the water, in whatever ſituation the fiſh may be; and they ſerve rather to raiſe or depreſs the fiſh, than to aſſiſt its progreſſive motion. The dorſal fin is ſituate along the ridge of the back; and ſerves to keep it in equilibrio. In many fiſhes this is wanting; but in all flat fiſhes it is very large, as the pectoral fins are proportionably ſmall. Laſtly, the tail, which in ſome fiſhes is flat, and upright in others, ſeems the grand inſtrument of motion; the fins are all ſubſervient to it, and give direction to its impetus, by which the fiſh darts forward with ſo much velocity. To explain all this, by experiment, a carp is taken, and put into a large

veſſel.

veſſel. The fiſh, in a ſtate of repoſe, ſpreads all its fins, and ſeems to reſt upon its pectoral and ventral fins near the bottom: if the fiſh folds up either of its pectoral fins, it inclines to the lame ſide; folding the right pectoral fin, the fiſh inclines to the right ſide; folding the left fin, it inclines to that ſide. When the fiſh deſires to have a retrogade motion, ſtriking with the pectoral fins, in a contrary direction produces it. If the fiſh deſires to turn, a blow from the tail, ſends it about; but if the tail ſtrikes both ways, then the motion is progreſſive.

10. There is ſomething extremely odd in the experiments of an ingenious man, on ſome of our common fiſhes.

"I put a banſtickle, ſays he, in a glaſs jar filled with water: at firſt it refuſed to eat any thing, which is common with all fiſhes; but afterward it grew ſo tame, as to take ſmall worms out of my hand. Nay, it was ſo bold at laſt, that when its belly was full, it would ſet up its prickles, and with all its ſtrength, make a ſtroke at my fingers, if I put them near it.

"This fiſh was ſo unſociable, that it would ſuffer no other fiſh to live in the jar with it, and ſo audacious as to attack whatever I put in, though ten times its own ſize. One day I put in a ſmall ruff; the banſtickle inſtantly aſſaulted it, and tore off part of its tail, and I am perſuaded would have killed it, had I not ſeparated them.

"The abilities they uſe to get from place to place, are likewiſe extraordinary. Though they are ſcarce two inches long, I have ſeen them leap out of the water a foot high perpendicularly, and much farther obliquely, when they wanted to get over ſome obſtacle in their way.

"Nature has furniſhed them with a kind of breaſtplate, to be a defence againſt outward injury, and with prickles upon their ſides and back, which they erect on the leaſt appearance of danger.

"I have always obſerved among the fiſh I keep in jars, that ſuch as I keep awhile together, contract ſo great an affection for each other, that if they are ſeparated, they grow melancholy and ſullen. About

Chriſtmas

Chriſtmas I put two ruffs into a jar, where they lived together till April. I then gave one of them to a friend, the other was ſo affected, that for three weeks it would eat nothing. Fearing it would pine to death, I ſent it to its companion: being put to this, it ate immediately, and preſently recovered its former briſkneſs."

"In the beginning of September," ſays the ſame gentleman, "I procured a ſmall dace, which I kept in a glaſs jar till the latter end of May following. All this while it ate nothing except the ſmall animalcules, which happened to be in the water I gave it, once a day in winter, and twice or thrice in the ſpring, as the weather grew warmer. When the water was freſh, it came up to the top about once an hour, to blow out ſome ſmall bubbles of air. Then putting its noſe near the ſurface, it took in freſh, and retired to the bottom again. But as the water became leſs pure by its uſe, its returns to the ſurface were more frequent, and at laſt it would remain there continually, till I gave it a freſh quantity. I believe I might have kept it for years, but buſineſs one day prevented me from giving it clean water in due time, which put a period to the life of my little companion.

"At firſt it would not ſuffer me to come nigh the glaſs, without the utmoſt confuſion and ſurpriſe; but at laſt it grew ſo tame, that if I came but in ſight, it would be ſure to be at the ſame ſide of the glaſs, and lie gazing at me, until I was weary of obſerving it. I often took the opportunity of looking at it by candle-light, which it ſeemed to take great pleaſure in.

"In the above-mentioned month, I put into another glaſs, a ruff about three inches long. At firſt he too appeared mighty reſerved, and would not eat, nor ſuffer me to come nigh him; but in a ſhort time all-powerful hunger tamed him: for he could not, like the dace, live on the ſmall inhabitants of the water, and ſo was quickly forced to take whatever I provided for him. In a while it grew ſo tame, that it would not only eat ſmall worms which I threw into the glaſs, but would take them out of my hands. Nay, it would

even riſe out above the water for them; which is contrary to the way wherein this kind of fiſh uſes to take its food. At laſt, it would come to my hand, whenever I put it into the glaſs, and ſuffer me to handle it. When I had made all the obſervations I thought proper, after eight months I gave him his liberty."

11. It has long been ſuppoſed that all ſhells, as well as the animals in them, aroſe wholly from the egg.—But it is now found by various experiments, that the ſhells of ſnails (and probably of all other animals) are formed of a matter which perſpires from their bodies, and then condenſes round them.

It is certain all animals perſpire and are encompaſſed with the atmoſphere which exhales from them. Snails have nothing peculiar in this reſpect, unleſs that their atmoſphere condenſes and hardens about them, and forms a viſible cover for the body, while that of other animals evaporates. This difference may ariſe from the different ſubſtance perſpired; that from ſnails being viſcous and ſtony. This is no ſuppoſition, but a matter of fact, proved by numerous experiments.

But the re-production of the ſhells of ſome fiſh, yea, and of the parts contained therein, is far more ſtrange and unaccountable, than their firſt production. This is particularly obſerved in crabs and lobſters. Lobſters caſt their ſhells yearly, ſome time after midſummer.—In the room of the old, a new, thin ſhell is immediately prepared by nature, which in leſs than eight days, acquires almoſt the ſame degree of hardneſs as the other.

The legs of a lobſter conſiſt of five articulations.—When any of theſe legs break, which frequently happens, the fracture is always near the fourth joint, and what they loſe is preciſely re-produced in ſome time after: four joints ſhooting out, the firſt whereof has two claws, as before.

If a leg be broken off purpoſely at the fourth or fifth joint, it is conſtantly re-produced: but very rarely, if at the firſt, ſecond, or third joint. What is ſtill more ſurpriſing is, that upon viſiting the lobſter, which is maimed in theſe barren articulations, at the end of two or three days, all the other joints are found broken

ken off at the fourth, which he has undoubtedly done himſelf.

The part re-produced is perfectly like that broke off, and in a certain time grows equal to it. Hence it is, that lobſters have often their two big legs unequal. This ſhews the ſmaller leg to be a new one. If a part thus re-produced is broken off, there is a ſecond reproduction. The ſummer, which is the only time when lobſters eat, is the moſt favourable time for this. It is then performed in four or five days; otherwiſe it takes up eight or nine months.

The common crab-fiſh has its abode from twenty to forty fathom water. They herd together in diſtinct tribes, and have their ſeparate haunts for feeding and breeding, and will not aſſociate with their neighbours. This has been tried, by marking a crab, carrying it two or three miles, and leaving it among other crabs. This crab has afterward found its way home, and been caught in its old abode.

This creature too can break off its own limbs. If when it is laid on its back, one of the outer joints of a ſmall leg be bruiſed, he ſhews uneaſineſs, by moving it about. Afterward he holds it quite ſtill, in a direct and natural poſition, without touching any part of the body, or of the other legs with it. Then on a ſudden with a gentle crack, the wounded part of the leg drops off. If a hole be pierced in the great leg, the effect will be the ſame; and the large limb is thrown off in the ſame manner, only with greater violence. A mucus then overſpreads the wound, which preſently ſtops the bleeding; and a ſmall leg is by degrees produced, which gradually attains the ſize of the former. Nature has given this ſingular power to theſe creatures, for the preſervation of their lives in their frequent quarrels. In theſe, one crab lays hold of the claw of another, and cruſhes it in ſuch a manner, that it would bleed to death, had it not the power of giving up the limb, and healing the wound.

However different in figure the lobſter and the crab may ſeem, their manners are nearly the ſame. Though without any warmth in their bodies, or even red blood,

they

they are wonderfully voracious. Whatever they ſeize upon that has life, is ſure to periſh, though never ſo well defended: they even devour each other; and, to increaſe our ſurpriſe, they may, in ſome meaſure, be ſaid to eat themſelves, as they change their ſhell and their ſtomach every year, and their old ſtomach is generally the firſt morſel that ſerves to glut the new.

What this animal differs in from all others, is, that the ſpinal marrow is in the breaſt-bone. It is furniſhed with two long feelers or horns, that iſſue on each ſide of the head, to correct the dimneſs of its ſight, and apprize the animal of its danger, or of its prey. The tail is the grand inſtrument of motion; and with this it can raiſe itſelf in the water.

When the young lobſters leave the parent, they ſeek for refuge in the ſmaller clefts of rocks, and in crevices at the bottom of the ſea. There they grow larger in a few weeks, from the accidental ſubſtances which the water waſhes to their retreats. By this time alſo they acquire a hard firm ſhell, which furniſhes them with both offenſive and defenſive armour. They then iſſue from their fortreſſes, and creep along the bottom, in hopes of meeting with plunder. The ſpawn of fiſh, the ſmaller animals of their own kind, but chiefly the worms that keep at the bottom of the ſea, ſupply them with plenty. They keep in this manner cloſe among the rocks, buſily employed in ſcratching up the ſand with their claws for worms, or ſurpriſing ſuch heedleſs animals as fall within their graſp: thus they have little to apprehend, except from each other, for in them, as among fiſhes, the large are the moſt formidable of all enemies to the ſmall.

But the body of the lobſter ſtill continuing to increaſe, the animal ſoon becomes too large for its habitation. In general, all animals change their ſhell once a year; and this is a moſt painful operation.—Their moulting ſeaſon is generally about the beginning of ſummer; at which time their food is in plenty, and their ſtrength and vigour in the higheſt perfection.—But ſoon all their activity ceaſes: they ſeek ſome retired ſituation among the rocks, where they remain in ſafety from the attacks of their various enemies. For ſome days before their change, the animal diſcontinues

tinues its uſual voracioufneſs; it is no longer ſeen harrowing up the ſand at the bottom, or fighting with others of his kind, or hunting its prey: it lies torpid and motionleſs. Juſt before caſting its ſhell, it throws itſelf upon its back, ſtrikes its claws againſt each other, and every limb ſeems to tremble; its feelers are agitated, and the whole body is in violent motion. It then ſwells itſelf in an unuſual manner, and at laſt the ſhell begins to divide at its junctures; particularly at the junctures of the belly, where like a pair of jumps, it was before but ſeemingly united. It alſo ſeems turned inſide out; and its ſtomach comes away with its ſhell. After this it diſengages itſelf of the claws, which burſt at the joints; the animal, with a tremulous motion, caſting them off, as a man would kick off a boot that was too big for him.

Thus this wonderful creature is at liberty; but ſo weak that it continues for ſeveral hours motionleſs.—Indeed, ſo violent and painful is the operation, that many of them die under it; and thoſe which ſurvive, for ſome time neither take food, nor venture from their retreats. Immediately after this change, they have not only the ſoftneſs, but the timidity of a worm. Every animal of the deep is then a powerful enemy, which they can neither eſcape, nor oppoſe; and this is the time when the dog-fiſh, the cod, and the ray devour them by hundreds. But this ſtate continues for a very ſhort time: in leſs than two days, the ſkin that covered his body is grown almoſt as hard as before.

When the lobſter is completely equipped in its new ſhell, it appears how much it has grown in the ſpace of a very few days. The old ſhell being compared with thoſe of the new, it is increaſed above a third in its ſize; and, like a boy that has outgrown his clothes, it ſeems wonderful how the deſerted ſhell was able to contain ſo great an animal as entirely fills up the new.

It may be worth obſerving, that lobſters uſe their tails as fins, wherewith they commonly ſwim backward, by jerks or ſprings, reaching ſometimes ten yards at a ſpring. For this purpoſe, as the gill-fins of other fiſhes, which are their oars, are a little concave

cave backward, theſe have the plates of their tails, when they bend them down as they uſe to do, a little concave forward.

Different from all theſe are the land crabs of the Caribbee Iſlands; which live in a kind of orderly ſociety, within their retreats in the mountains; and regularly once a year march down to the ſea ſide in a body of ſome millions. They chuſe the months of April and May to begin their expedition: and then ſally out from the ſtumps of hollow trees, from the clefts of rocks, and from the holes which they dig for themſelves under the ſurface of the earth. At that time the whole ground is covered with this band of adventurers. The ſea is their place of deſtination, and to that they direct their march. No geometrician could ſend them to their deſtined ſtation, by a ſhorter courſe. They never turn to the right or left, whatever obſtacles intervene. And even if they meet with a houſe, they will attempt to ſcale the walls, to keep the unbroken tenor of their way. But upon ſome occaſions they are compelled to conform to the face of the country; and if it be interſected by rivers, the wind along the courſe of the ſtream. They are commonly divided into three battalions; of which, the firſt conſiſts of the ſtrongeſt and boldeſt males, that like pioneers, march forward to clear the route, and face the greateſt dangers. Theſe are often obliged to halt for want of rain, and wait till the weather changes.—The main body of the army is compoſed of females, which never leave the mountains till the rain is ſet in, and then deſcend in regular battalia, in columns of fifty paces broad, and three miles deep, and ſo cloſe, that they almoſt cover the ground. Three or four days after this, the rear-guard follows; a ſtraggling undiſciplined tribe, conſiſting of males and females, but neither ſo robuſt, nor ſo numerous as the former.—The night is their chief time of proceeding; but if it rains by day, they do not fail to profit by the occaſion. And they continue to move forward in their ſlow, uniform manner. When the ſun ſhines hot, they make an univerſal halt, and wait till the cool of the evening.—When they are terrified, they march back in a diſorderly

derly manner, holding up their nippers with which they ſometimes tear off a piece of the fleſh of an aſſailant, and leave the weapon where they inflicted the wound. They often clatter their nippers together, as if it were to threaten thoſe that come to diſturb them. But though they thus ſtrive to be formidable to man, they are much more ſo to each other; for if any of them by accident is maimed in ſuch a manner, as to be incapable of proceeding, the reſt fall upon and devour it on the ſpot, and then purſue their journey.

When after a fatiguing march, perhaps of three months, they arrive at their deſtined port, they prepare to caſt their ſpawn. The peas are as yet within their bodies, and not as is uſual in animals of this kind, under the tail. And the creature waits for the benefit of the ſea-water, to help the delivery. For this purpoſe, the crab has no ſooner reached the ſhore, than it eagerly goes to the edge of the water, and lets the waves waſh over its body, two or three times. Then they withdraw to ſeek a lodging upon land: in the mean time, the ſpawn grows larger, is excluded out of the body, and ſticks to the barbs under the tail. In this ſtate of pregnancy, they once more ſeek the ſhore, and ſhaking off their ſpawn into the water, leave it there. At this time whole ſhoals of hungry fiſh are in expectation of this annual ſupply. The ſea to a great diſtance is black with them; and about two thirds of the crabs eggs are immediately devoured. The eggs that eſcape are hatched under the ſand; and ſoon after millions at a time of theſe little crabs are ſeen quitting the ſhore, and ſlowly travelling up to the mountains.

The old ones however are not ſo active to return; they are become ſo feeble, that they can hardly creep along. Moſt of them, therefore, are obliged to continue in the flat parts of the country till they recover, making holes in the earth, which they cover at the mouth with leaves and dirt. There they throw off their old ſhells. At that time they are quite naked, and almoſt without motion for ſix days. They have then under their ſtomachs four large white ſtones, which gradually decreaſe in proportion as the ſhell hardens, and when they come to perfection, are not to be found. It is at that time the animal is ſeen ſlowly

making

making its way back, and all this is commonly performed in ſix weeks.

There is likewiſe an animal of the lobſter-kind that annually deſcends from its mountains, not only to produce an offſpring, but to provide itſelf a covering; not only to ſecure a family, but to furniſh a houſe. I mean the ſoldier crab. It is about four inches long, has no ſhell behind, but is covered down to the tail with a rough ſkin, terminating in a point. But what nature has denied this animal, it takes care to ſupply by art; and taking poſſeſſion of the deſerted ſhell of ſome other animal, it reſides in it, till, by growing too large for its habitation, it is under the neceſſity of a change. It is a native of the Weſt India Iſlands, and every year deſcends from the mountains to the ſea-ſhore, to depoſit its ſpawn, and to provide itſelf with a new ſhell. Its firſt care is to provide for its offſpring, and it is thought, from the number of little ſhells which it is ſeen examining, that it depoſits its ſpawn in them, which thus is placed in perfect ſecurity till the time of excluſion.

It is then mindful of itſelf. It is ſtill ſeen in its old ſhell, which it has conſiderably outgrown: a part of the naked body is ſeen at the mouth of it, which the habitation is too ſmall to hide. A ſhell therefore, is to be found large enough to cover the whole body; and yet not ſo large as to be unmanageable. To anſwer both theſe ends is no eaſy matter, nor the attainment of a ſlight inquiry. The little ſoldier is ſeen buſily parading the ſhore along that line of pebbles and ſhells that is formed by the waves; ſtill, however, dragging its old habitation at his tail; unwilling to part with one ſhell, till it can find another more convenient. It is ſeen ſtopping at one ſhell, turning it and paſſing it by, going on to another, contemplating that for awhile, and then ſlipping its tail from its old habitation, to try on the new. This alſo is found to be inconvenient, and it quickly returns to its old ſhell again. In this manner it frequently changes, till at laſt it finds one, light, roomy, and commodious. To this it adheres, though the ſhell be ſometimes ſo large as to hide the body of the animal, claws and all.

Yet

Yet it is not till after many trials, and many combats alſo, that the ſoldier is thus completely equipped. For there is often a conteſt between two of them, for ſome well-looking ſhell. They both endeavour to take poſſeſſion: they ſtrike with their claws; they bite each other, till the weakeſt is obliged to yield. It is then that the victor takes poſſeſſion, and parades in his new conqueſt three or four times backward and forward upon the ſtrand, before his envious antagoniſt.

Crabs-eyes, ſo called, are found in the bodies of cray-fiſh. Each fiſh produces two yearly, one on each ſide of the ſtomach, between the coats of it. Here it grows, coat upon coat, and is ſupplied with petrifying juices, by veſſels opening on the inner ſurface of the outward coat. The firſt ſcale, whereon all the others are formed, may be perceived in the centre; the brims or circumferences of many of the reſt being likewiſe apparent. It is believed, that they caſt theſe ſtones with their ſhells yearly; but this is not the caſe. For about the time of caſting their ſhell, the ſtones break through the internal coat of the ſtomach, and being ground by the three ſerrated teeth therein, become diſſolved in the ſpace of a few days, which makes it difficult to find them juſt at this time.

They eat their old ſhells immediately after ſhedding them. Perhaps theſe ſtones may be deſigned to furniſh new petreſcent juices to its fluids, for the re-production of their annual dreſs.

As to turbinated ſhell-fiſh of the ſnail-kind, we may firſt obſerve the ſnail itſelf. This is ſurpriſingly fitted for the life it is to lead. It has the organs of life in a manner almoſt as complete as the largeſt animal; a tongue, brain, ſalival ducts, glands, nerves, ſtomach, and inteſtines; liver, heart, and blood veſſels: beſides this it has a purple bag that furniſhes a red matter to different parts of the body, together with ſtrong muſcles, that hold it to the ſhell, and which are hardened like tendons at their inſertion.

But theſe it poſſeſſes in common with other animals. We muſt now ſee what it has peculiar to itſelf. The ſtriking peculiarity is, it has got its eyes on the points of

of its largeſt horns. When the ſnail is in motion, four horns are ſeen diſtinctly; but the two longeſt deſerve peculiar conſideration, both on account of the various motions with which they are endued, and of their having eyes at the extreme ends of them. Theſe appear like two blackiſh points. The animal can direct them to different objects at pleaſure, by a regular motion out of the body; and ſometimes it hides them by a very ſwift contraction into the belly. Under the ſmall horns is the animal's mouth; and though it may appear too ſoft a ſubſtance to be furniſhed with teeth, yet it has no leſs than eight of them, with which it devours leaves, and other ſubſtances ſeemingly harder than itſelf.

It may ſeem whimſical to make a diſtinction between the animal perfections of turbinated and bivalved ſhellfiſh, or grant a degree of ſuperiority to the ſnail above the oyſter. Yet this diſtinction apparently obtains in nature; and we ſhall find the bivalved tribe of animals in every reſpect inferior to the other. Inferior in all their ſenſations; inferior in all their motions; but peculiarly inferior in their ſyſtem of animal generation. The ſnail tribe are hermaphrodite; but require the aſſiſtance of each other for fecundation; all the bivalve tribe are hermaphrodite in like manner, but they require no aſſiſtance from each other towards impregnation; and a ſingle muſcle or oyſter, if there were no other in the world, would quickly repleniſh the ocean.

The multitude of muſcles is in ſome places very great; but from their defenceleſs ſtate, the number of their deſtroyers are in equal proportion. The crab, the cray-fiſh, and many other animals are ſeen to devour them; but the tochus is their moſt formidable enemy. When their ſhells are found deſerted, if we then obſerve cloſely, it is moſt probable we ſhall find that the tochus has been at work in piercing them. There is ſcarce one of them without a hole in it; and this probably was the avenue by which the enemy entered to deſtroy the inhabitant.

But notwithſtanding the number of this creature's animated enemies, it ſeems ſtill more fearful of the agitations of the element in which it reſides; for if daſhed againſt rocks, or thrown far on the beach, it is

deſtroyed

deſtroyed without a power of redreſs. In order to guard againſt theſe, which are to this animal the commoneſt and the moſt fatal accidents, although it has a power of ſlow motion, which I ſhall preſently deſcribe, yet it endeavours to become ſtationary, and to attach itſelf to any fixed object it happens to be near. For this purpoſe it is furniſhed with a very ſingular capacity of binding itſelf by a number of threads to whatever object it approaches; and theſe Reaumur ſuppoſes it ſpins artificially, as ſpiders their webs, which they faſten againſt a wall. Be this as it will, nothing is more certain than that the muſcle is found attached by theſe threads to every fixed object; ſometimes, indeed, for want of ſuch an object, theſe animals are found united to each other, and though thrown into a lake ſeparately, they are taken out in bunches of many together.

To have ſome fixed reſting place, where the muſcle can continue, and take in its accidental food, ſeems the ſtate that this animal chiefly deſires. Its inſtrument of motion, by which it contrives to reach the object it wants to bind itſelf to, is that muſcular ſubſtance reſembling a tongue, which is found long in proportion to the ſize of the muſcle. This the animal has a power of thruſting out of its ſhell; and with this it is capable of making a ſlit in the ſand at the bottom. By means of this furrow in proportion as it goes forward, it reaches out its tongue, that anſwers the purpoſe of an arm, and thus carries its ſhell edge-ways, as in a groove, until it reaches the point intended. Then where it determines to take up its reſidence, it fixes the ends of its beard, which are glutinous, to the rock, or the object, whatever it be; and thus like a ſhip at anchor, braves all the agitations of the waters. Sometimes the animal is attached by a large number of threads; ſometimes but by three or four, that ſeem ſcarce able to retain it. When the muſcle is fixed in this manner, it lives upon the little earthy particles that the water tranſports to its ſhells, and perhaps the fleſh of the moſt diminutive animals. However, it does not fail to grow conſiderably; and ſome of this kind have been found a foot long. I have ſeen the beards of a foot and a half; and of this ſubſtance the natives of Palermo make gloves and ſtockings.

Oyſters

Oyſters uſually caſt their ſpawn in May, which at firſt appear like drops of candle-greaſe, and ſtick to any hard ſubſtance they ſtick upon. Theſe are covered with a ſhell in two or three days, and in three years the animal is large enough to be brought to market.

The ſcallop is particularly remarkable for its method of moving forward upon land, or ſwimming upon the water. When it finds itſelf deſerted by the tide, it moves towards the ſea in a moſt ſingular manner. It firſt gapes with its ſhell as widely as it can, the edges being often an inch aſunder; then it ſhuts them with a jerk, and by this the whole animal riſes five or ſix inches from the ground. It thus tumbles any how forward, and renews the operation until it has attained its journey's end. When in the water it is capable of ſupporting itſelf on the ſurface; and there opening and ſhutting its ſhells, it tumbles over and over, and makes its way with ſome celerity.

The razor-ſhell has a very different kind of motion. As the former moves laborioufly forward, ſo the razor-ſhell has only a power of ſinking downward. The ſhells of this animal reſemble nothing ſo much as the haft of a razor; and by this form it is enabled to dive into the ſoft ſand. All its motions are confined to ſinking or riſing a foot downwards or upwards in the ſand, for it never leaves the ſpot where firſt it was planted. From time to time it riſes about half-way out of its hole: but if any way diſturbed ſinks perpendicularly down again. Juſt over the place where the razor buries itſelf, there is a ſmall hole like a chimney, through which the animal breathes or imbibes the ſea-water. Upon the deſertion of the tide, theſe holes are eaſily diſtinguiſhed by the fiſhermen; and their method of enticing the razor up is by ſprinkling a little ſea-ſalt upon the hole. This melting, no ſooner reaches the razor below, than it riſes inſtantly, and ſhews above half its length above the ſurface. This appearance is inſtantaneous; and if the fiſher does not ſeize the opportunity, the razor buries itſelf to its former depth. There it continues ſecure; no ſalt can allure it a ſecond time; but it remains unmoleſted unleſs the fiſher will be at

the

the trouble of digging it out, ſometimes two feet below the ſurface.

Multivalve ſhell-fiſh may be conſidered as animals ſhut up in round boxes. To view their habitations externally, one would be little apt to conſider them as the retreats of living creatures; and ſtill leſs, to ſuppoſe that ſome of them carry their boxes with a tolerable ſhare of ſwiftneſs, ſo as to eſcape their purſuers. Of theſe are principally two kinds; ſuch as move, and ſuch as are ſtationary: the firſt are uſually known in our cabinets by the name of ſea-eggs; the others are often admired for the cavities which they ſcoop out for their habitation in the hardeſt marble. The firſt are called, by naturaliſts, echini, or urchins: the latter are called pholades, or file-fiſh. Of both theſe are ſeveral ſorts; but deſcribing theſe two, we ſhall have a competent idea of all the reſt.

To a ſlight view, the ſea-urchin may be compared to the huſk of a cheſnut; being like it, round, and with a number of bony prickles ſtanding out on every ſide. If we could conceive a turnip ſtuck full of pins on every ſide, and running upon theſe pins with ſome degree of ſwiftneſs, we ſhould have ſome idea of this extraordinary creature. The mouth is placed downwards; the vent is above; the ſhell is a hollow vaſe, reſembling a ſcooped apple; and this filled with a ſoft muſcular ſubſtance, through which the inteſtines wind from the bottom to the top. The mouth, which is placed undermoſt, is large and red, furniſhed with fine ſharp teeth, which are eaſily diſcerned. The jaws are ſtrengthened by fine ſmall bones, in the centre of which is a ſmall fleſhy tongue; and from this the inteſtines make a winding of five ſpires, round the internal ſides of the ſhell, ending at the top, where the excrements are excluded. But what makes the moſt extraordinary part of this animal's conformation, are its horns, and its ſpines, that point from every part of the body, like the horns of a ſnail, and that ſerve at once as legs to move upon, as arms to feel with, and as inſtruments of capture and defence. Between their horns it has alſo ſpines that are not endued with ſuch a ſhare of motion.

The

The ſpines and the horns iſſue from every part of the body, the ſpines being hard and prickly, the horns being ſofter, longer than the ſpines, and never ſeen except in the water. They are put forward and withdrawn like the horns of a ſnail, and are hid at the baſs of the ſpine, ſerving, as was ſaid before, for procuring food and motion. All this apparatus, however, is only ſeen when the animal is hunting his prey at the bottom of the water: for a few minutes after it is taken, all the horns are withdrawn into the body, and moſt of the ſpines drop off.

It is generally ſaid of inſects, that thoſe which have the greateſt number of legs, always move the ſloweſt; but this animal ſeems to be an exception to the rule; for though furniſhed with two thouſand ſpines, and twelve hundred horns, all ſerving for legs, and which from their number ſeem to impede each others motion, yet it runs with ſome ſhare of ſwiftneſs at the bottom, and it is ſometimes no eaſy matter to overtake it.

Very different in motion, though not much different in ſhape from them, are the acorn ſhell-fiſh, the thumb-footed ſhell-fiſh, and the imaginary barnacle. Theſe are fixed to one ſpot, and appear to vegetate from a ſtalk. Indeed, to an inattentive ſpectator, each actually ſeems to be a kind of fungus that grows in the deep, deſtitute of animal life, as well as motion. But the inquirer will ſoon change his opinion, when he comes to obſerve the muſhroon-like figure more minutely. He will then ſee that the animal reſiding within the ſhell, has not only life, but ſome degree of voraciouſneſs; that it has a cover, by which it opens and ſhuts its ſhell at pleaſure; that it has twelve large crooked arms, furniſhed with hair, which it thruſts forth for its prey; and eight ſmaller, which are generally kept in the ſhell. They are ſeen adhering to every ſubſtance that is to be met with in the ocean; rocks, roots of trees, ſhips bottoms, whales, lobſters, and even crabs; like bunches of grapes clung to each other. It is amuſing enough to behold their operations. They for ſome time remain motionleſs within their ſhell; but when the ſea is calm, they are ſeen opening the lid, and peeping about them. They then thruſt

thruſt out their long neck, look round them for ſome time, and then abruptly retreat back into their box, ſhut the lid, and lurk in darkneſs and ſecurity.

Among the ſhell-fiſh on the Waterford coaſt, is the murex, which have the Tyrian purple. It is in great plenty there, and is by the Engliſh called a horſe-winkle. The ſhell is about an inch long, and half an inch broad, and turns ſpirally like a ſnail-ſhell. Each fiſh has a peculiar reſervoir, which contains a large drop of liquor: if this is preſſed out on linen, the linen firſt appears of a dirty yellow, inclining to green, afterward it changes to a lemon colour, then to a deep green; then it turns to a deep blue, and at laſt to a charming purple.

The ſhells of the ancient purple-fiſh, are ſtill common on the Tyrian ſhore. The fiſh itſelf is found in great abundance in the ſeas of the Spaniſh Weſt-Indies, near Panama and Nicoya, exactly agreeing with Pliny's account of the ancient murex. Cloth of Segovia, died with this purple, is ſold for twenty crowns an ell, and is very rarely worn by any, but the greateſt noblemen in Spain. The Caribbee Iſlands have alſo the ſame ſort of fiſh, which we may likewiſe find nearer home, namely on the coaſts of Somerſetſhire, as well as of South-Wales.

The pearl muſcles lie partly open: the inſide of the ſhell is of a pearly colour. The pearl lies in the ſmaller end of it, at the extremity of the gut, and out of the body of the fiſh, between the two films that line the ſhell. This anſwers to the ſtone in other animals, increaſing by cruſts growing over one another. Accordingly if a pearl be pinched in a vice, the upper coat will crack and leap away. And as it is now known, that the ſhells of fiſhes are formed of ſtony matter oozing out of their body, it is no wonder if that matter when it chances to overflow, burſts forth in any cavity of the body, and forms a little maſs, which hardening, becomes a pearl of the ſame colour with the ſhell.

Whereas all other animals take in nutriment by the mouth,

mouth, the muſcle takes it in by the anus. The part called the head, though without eyes, ears, or tongue, is immoveably faſtened to one of the ſhells ſo that it cannot receive any thing. The food of a muſcle is water, which as the ſhell opens, enters in at the anus, and paſſing on by certain canals running between the ſhell and the animal, is thence conveyed into the mouth.

We have lately diſcovered a progreſſive motion in thoſe ſhell-fiſh, which were ſuppoſed to be quite fixed. Even oyſters, which one would think wholly immoveable, if they are thrown irregularly into a veſſel of water, will in a while turn themſelves till the ſmooth ſhell becomes uppermoſt: otherwiſe they could hold no water in the concave ſhell for their ſuſtenance.

Muſcles can walk on the ground, which they do in this manner. Lying on the flat ſide of their ſhell, they thruſt out a part, in form of a tongue, wherewith they make little motions to the right and left, and thereby dig a paſſage in the ſand. In this digging they drop gradually on one ſide, and ſo get the ſhell mounted on its edge; then they ſtretch out the tongue as far as they can, and reſt for a minute or two on its extremity to draw the ſhell after them, as water-ſnails do. This motion is repeated as long as they pleaſe; thus they form a ſort of groove in the ſand, which ſuſtains the ſhell on either ſide, and leaves behind them a ſort of irregular tract, three or four yards long. In rivers abounding with muſcles one may ſee many of them, with a muſcle at the end of each.

That called the arm or a leg in a ſea-muſcle, which in its natural ſtate is not above two lines long, may reach out of the ſhell two inches: and the muſcle having laid hold on a fixed point therewith, bends and ſhortens it and ſo drags itſelf on. The beard ſerves for an anchor to faſten it to ſome heavy body, that it may not be carried away with the motion of the waves.

When a pond-muſcle walks, it thruſts out its whole belly, in form of the keel of a ſhip, and creeps on the belly as the ſerpent does. So true it is, that nature is not confined in her manner of operation, but is ever varying, though never confuſed.

In

In Port-Mahon harbour, there are ſtones from half a hundred to five hundred weight each, lying at all depths, full of ſhells, each containing a ſingle fiſh, of the muſcle-kind. The holes in the ſurface are far narrower than the hole in which is the fiſh, which it ſeems is capable of enlarging its room as it grows bigger, by abrading the ſizes of its cells. And this is apparent, from the ſandy matter found in the bottom of thoſe cells, whenever the orifice is higher than the bottom; for then the fiſh cannot throw it out.

The bollani likewiſe in the Adriatic ſea, live in large ſtones. Their ſhell is rough and oblong, not unlike a date. They are found in ſeveral kinds of porous ſtones. In the pores of theſe the ſpawn is depoſited. Frequently the aperture, through which it was injected, is no longer perceivable; but the fiſh thrives notwithſtanding. On breaking ſome of theſe ſtones, one finds near thirty live fiſh, though no opening can be perceived on the outſide. Each has juſt room to open its ſhell, the inſide of which is white, the outſide aſh-colour; the largeſt is four or five inches long. Both the fiſh itſelf and its juices are ſo luminous, one may ſee to read by it; and even water in which it has been ſqueezed, put into a glaſs, will ſhine ten or twelve hours.

Likewiſe in Toulon harbour are found ſolid ſtones, containing in ſeparate cells, ſecluded from all communication with the air, ſeveral living ſhell-fiſh. The ſame are found along the coaſt of Alcona, in ſtones weighing fifty pounds and upwards. The outſide of which is ſoft, but the inſide ſo hard as to require an iron mall, and a ſtrong arm to break them.

Pholades bollani, when diveſted of their ſhells, reſemble a roundiſh, ſoft pudding, with no inſtrument that ſeems in the leaſt fitted for boring into ſtones, or even penetrating the ſofteſt ſubſtance. A pholas is furniſhed with two teeth indeed; but theſe are placed in ſuch a ſituation as to be incapable of touching the hollow ſurface of its ſtony dwelling. It has alſo two covers to its ſhell that open and ſhut at either end; but

theſe are totally unſerviceable to it as a miner. The inſtrument with which it performs all its operations, and buries itſelf in the hardeſt rocks, is only a broad fleſhy ſubſtance, ſomewhat reſembling a tongue, that is ſeen iſſuing from the bottom of its ſhell. With this ſoft yielding inſtrument, it perforates the moſt ſolid marbles; and having, while little and young, made its way, by a very narrow paſſage into the ſubſtance of the ſtone, it then begins to grow bigger, and thus to enlarge its apartment. While yet naked and very ſmall, it has effected an entrance, and has buried its body in the ſtone: it there continues for life at its eaſe; the ſea-water that enters at its apertures ſupplying it with luxurious plenty. When the animal has taken too great a quantity of water, it is ſeen to ſpurt it out of its hole with ſome violence. Upon this ſeemingly thin diet, it quickly grows larger, and ſoon finds itſelf under a neceſſity of enlarging its habitation and its ſhell. The motion of the pholas is ſlow beyond conception; its progreſs keeps pace with the growth of its body; and in proportion as it grows larger, it makes its way farther into the rock. When it has got a certain way in, it then turns from a certain direction, and hollows downward; till at laſt when its habitation is completed, the whole apartment reſembles the bowl of a tobacco-pipe: the hole is the ſhank, being that by which the animal entered.

Thus immured, the pholas lives in darkneſs, indolence, and plenty; it never removes from the narrow manſion into which it has penetrated: and ſeems perfectly content with being encloſed in its own ſepulchre. The influx of the ſea-water, that enters by its little gallery, ſatisfies all its wants; and without any other food, it is found to grow from ſeven to eight inches long, and thick in proportion.

Yet the pholas thus ſhut up is not ſo ſolitary an animal as it would at firſt appear; for though it is immured in its hole without egreſs; though it is impoſſible for the animal, grown to a great ſize, to get out by the way it made in, yet many of this kind meet in the heart of the rock, and like miners in a ſiege, who ſometimes croſs each others galleries, they frequently break in upon each other's retreats: whether thei

thu

thus meeting be the work of accident or of choice, few can take upon them to determine; certain it is they are moſt commonly found in numbers in the ſame rock; and ſometimes above twenty are diſcovered within a few inches of each other.

As to the neſt, this animal is found in greateſt numbers at Ancona in Italy; it is found along the ſhores of Normandy and Poitou, in France; it is found alſo upon ſome of the coaſts of Scotland, and in general is conſidered as a very great delicacy at the tables of the luxurious.

One of the moſt extraordinary kinds of ſhell-fiſh is the animal-flower, in Barbadoes. In the pariſh of St. Lucy, on the north ſide of the iſland, there is a high rocky cliff fronting the ſea, near the bottom of which is a large cave. This opens into another cave, the bottom of which is a baſon of water. In the midſt of this baſon is a rock, always covered with water: on the ſides of which, a few inches below the water, are ſeen at all times of the year, iſſuing out of little holes, what have the appearance of finely radiated flowers, in ſize, colour and ſhape greatly reſembling a common marygold.

If you attempt to pluck one of theſe, as ſoon as your fingers come within two or three inches of it, it contracts, cloſes up its border, and ſhrinks back into the hole of the rock. But if left undiſturbed for a few minutes, it iſſues again, and ſoon appears in full bloom. This might induce one to believe, that it was no other than an aquatic ſenſitive plant.

But on a nearer inſpection we may diſcern four dark-coloured filaments, riſing from the centre, moving with a quick and ſpontaneous motion, and frequently cloſing, to ſeize its prey, much like the claws of a lobſter. So that the ſeeming flower is really an animal; and its body, which appeared to be the ſtalk of the flower, is black, about as big as a raven's quill.

It ſeems the vivid yellow colour of its feelers, is abſolutely neceſſary to procure its food. The water in the cave having no motion, cannot bring any food to them. Therefore the Creator has endued this creature with a quality which may allure its prey. For bright

colours invite many aquatic animals, as the flame of a candle does flies.

12. As to the generation of fiſhes, ſome of them are viviparous, others oviparous. The womb and ovaries of moſt fiſhes, are not unlike thoſe of birds. The female caſts out innumerable eggs, in the ſea, in lakes, in rivers. Great part of theſe are devoured by the males. The reſt are hatched by the warmth of the ſun, and the young ones immediately ſwim away, without any help from the parent.

Sea-tortoiſes lay their eggs on the ſea-ſhore, and cover them with the ſand. It is not uncommon to ſee a great number of young tortoiſes riſe out of the ſand, and without any guide or inſtructions, march with a gentle pace toward the water. But the waves uſually throw them back upon the ſhore, and then the birds deſtroy the moſt of them. So that out of two or three hundred of them it is ſeldom that ten eſcape.

It ſeems at firſt view, that nature, in this inſtance, charges herſelf with unneceſſary expenſe. But a little reflection ſhews the contrary. We do not complain of the fertility of a hen, which frequently lays above two hundred eggs in one year: although it may be, that not one chick is hatched out of all theſe. The deſign of the Author of nature is plain; not barely to preſerve the ſpecies, but at the ſame time, to provide man and other animals with an excellent food. So his intention in the fertility of a tortoiſe, is not barely to continue that ſpecies, but to accommodate a number of other animals with food convenient for them.

But whence could ariſe the common opinion concerning the generation of ſoles? namely, that they are produced from a kind of ſhrimps or prawns? A French gentleman being determined to try, put a large quantity of prawns into a tub about three feet wide, filled with ſea-water. At the end of twelve or thirteen days, he ſaw there eight or ten little ſoles, which grew by degrees. He repeated the experiment ſeveral times, and always found little ſoles. Afterwards he put ſome ſoles and prawns together, in one tub, and in another, ſoles alone.

alone. In both, the ſoles ſpawned; but there were no little ſoles, only in the tub where the prawns were.

But how can prawns be of uſe toward producing ſoles? Farther obſervations cleared up this. When ſhrimps or prawns are juſt taken out of the ſea, you may diſcern between their feet many little bladders, which are ſtrongly faſtened to their ſtomach, by a kind of glue. If you open theſe bladders gently, you ſee a ſort of embrios, which viewed with a microſcope, have all the appearance of ſoles.

Now here lies the myſtery. Theſe are the eggs or ſpawn of ſoles, which in order to hatch, are faſtened to the ſhrimps or prawns: like many plants and animals, which do not grow or receive nouriſhment, but upon other plants and animals. The prawns therefore are the foſter-mothers of ſoles, during their firſt infancy. And this has occaſioned many to imagine they were their real mothers.

The coming of certain kinds of fiſh in ſhoals to certain coaſts, at a certain time of the year, is of great advantage to mankind. But the reaſon of it has been little underſtood. Yet obſervation may clear it up. There is a ſmall inſect common in many ſeas, particularly on the coaſt of Normandy, in June, July, and Auguſt. They then cover the whole ſurface of the water as a ſcum. And this is the ſeaſon when the herrings come alſo in ſuch prodigious quantities. The fiſhermen deſtroy much of theſe vermin; yet to theſe alone their fiſheries are owing. For it is evident the herrings feed on theſe by the quantities found in all their ſtomachs. And doubtleſs, the very reaſon of their coming is to feed upon them. Probably the caſe is the ſame in all other places, where the herrings come in the ſame plenty.

The numberleſs ſwarms of herrings, cod, and other fiſh, that come forth yearly from their ſhelter, under the ice adjoining to the north pole, divide themſelves into three bodies. One part direct their courſe ſouthward, towards the Britiſh iſlands: another part weſtward, toward Newfoundland, and other places in North-America: and the third part along the coaſt of Norway, and then through the Sound into the Baltic.

The

The water, though quite ſtill before, curls up in waves wherever they come. They crowd together in ſuch numbers, that they may be taken up by pailfulls.

A large ſhoal of herrings, reaches (according to the fiſhermen's account) a hundred or two hundred fathoms deep. They extend alſo to a conſiderable circumference. Were they all to be caught, the greateſt part would be loſt. For it would be impoſſible to get hands, tubs, ſalt, and other neceſſaries to cure them. Several hundred ſhip-loads are ſent every year from Bergen alone to foreign parts: beſides the quantities that the peaſants at home conſume, who make them their daily proviſion.

The fiſhers on the weſtern iſles of Scotland obſerve, that there is a large herring, double the ſize of a common one, which leads all that are in the bay, the ſhoal following him wherever he goes. This leader they term the king of herrings: and when they chance to catch it alive, they drop it carefully into the ſea, judging it petty treaſon to deſtroy a fiſh of that name.

Mackrels come in the ſame numbers at certain times of the year; and for the ſame reaſon. They are particularly fond of a ſea-plant, the narrow-leaved, purple ſea-wick, which abounds on the coaſts of England; and is in its greateſt perfection in the beginning of ſummer: though at ſometimes later than other, according to the ſeverity or mildneſs of the winter.

The chief occaſion of their coming is to feed on this plant. And thoſe who attend to its growing up, would know when to expect the mackrel, better than thoſe who liſten for thunder.

But this is not the ſole occaſion of their coming. The real truth is this. The ſea near the pole is the native country of all fiſh of paſſage. The ice which continually covers that ſea, affords them a ſafe retreat. Large, voracious fiſh, want a free air for perſpiration, and cannot purſue the ſmaller ſort into their ſanctuaries, where they multiply ſo prodigiouſly, that at length for want of ſubſiſtence, they are forced to quit their retreat. The large fiſh wait for them at the extremity of the ice. They devour all they can catch, drive them cloſe into the coaſts, while the birds of

prey

prey pour down upon them from all quarters. In conſequence of this perſecution their march is always in columns, which are commonly as thick as they are broad. With regard to the herrings, they quit the ice in the beginning of the year. But the prodigious column which they form ſoon divides into two wings. The right moves weſtward, ſo as to be near Iceland in the month of March. The left bends its courſe eaſterly, and comes down the north ſea to a certain latitude, where it divides into two other wings, the eaſtern-moſt of which coaſts along Norway. Hence it ſends off one diviſion, by the ſtrait of the Sound, into the Baltic, another towards the country of Holſtein, Bremen, &c. and thence into the Zuderzee. The weſtern wing, which is the largeſt, falls directly upon the iſles of Shetland and the Orkneys. And thither the Dutch go to wait their coming. All that eſcape theſe dexterous fiſhers, go on to Scotland, and dividing again into two columns, one paſſes to the eaſt of that kingdom, and goes round England, detaching numerous diviſions to the coaſts of Frieſland, Holland, Zealand, Flanders, and France, while the other moves to the weſtward of Scotland and Ireland. The remains of the whole weſtern wing, which have eſcaped the nets of the fiſhers, and the voracity of other fiſh and fowl, having at length rallied in the channel, the column is formed anew; and then iſſues into the ocean: from which (without ſhewing itſelf again on the coaſt) it regains, like the remains of the firſt weſtern wing, which had not travelled ſo far, the polar ice, at the approach of winter. And under the protection of this, the loſs is repaired, which the ſpecies had ſuffered ſince they left it.

Thus does the divine wiſdom ſupply many thouſands of men with food, as well as numberleſs other animals; and yet prevent any decay of that neceſſary proviſion, which is continually conſumed and as conſtantly recruited.

The tunnies come in equal ſhoals at certain ſeaſons, to the coaſts of Provence and Languedoc, but it is on another occaſion. The fiſh called by the French, the Emperor, is the great enemy of theſe fiſh. He is in

ſummer

ſummer ſo plentiful in thoſe ſeas, that they cannot eſcape him by flying to the ſhallow waters.

The pilchards catched on the coaſt of Brittany, are ſtill a ſtronger proof, of the natural means that bring fiſh in ſhoals to certain places. The people of Brittany purchaſe from Norway, the offals and entrails of all the large fiſh caught there. Theſe they cut in pieces, and ſtraw in vaſt quantities on the ſea along the coaſts. This always brings thither ſhoals of pilchards, enough to ſupply all the maritime places in the neighbourhood.

The ſalmon (bred both in the ſea, and in rivers) is another fiſh, which comes in ſhoals at certain times. But this is on another occaſion. The female ſalmon chiefly ejects her roe at the mouth of rivers, in ſhallow water. The male comes preſently after, keeps other fiſh from devouring it, and caſts his ſperm upon the roe. They are in great plenty from the middle of April till the middle of July; at which time alſo they come in ſhoals into the rivers, partly to refreſh themſelves in freſh water, and partly to rub or waſh off in the ſtrong currents, a greeniſh vermin called ſalmon lice; inſects wiſely deſigned by the Creator, to drive this rich and valuable fiſh into the hands of men.

The ſalmon when they are going up the rivers out of the ſea, always ſwim as near the bottom as they can. And on the contrary, when they are going down them into the ſea, they always ſwim near the ſurface. The reaſon is, in going up, they ſwim againſt the current, which always runs ſwifteſt at the ſurface. When they are going down on the ſurface, the current alone is ſufficient to carry them.

At Leixlip, ſeven miles from Dublin, there is a fine water-fall, or ſalmon-leap, ſo called from the numberleſs ſalmon which leap up it, at the ſeaſon of the year for ſpawning. When they come to the foot of the fall, you may obſerve them frequently to leap up juſt above the water, as if to make an obſervation of the diſtance. Soon after they leap up again, with an attempt to gain the top, and perhaps riſe near it; but the falling water drives them down again. The ſame

fiſh

fiſh ſoon ſprings up again, and riſes above the fall: yet this is equally unſucceſsful, for dropping with their broadſides on the rapid curvature on the waters, they are thrown back again headlong. The only method of ſucceeding in their attempt, is to dart their heads into the water, in its firſt curvature over the rocks. By this means they firſt make a lodgment on the top of the rock for a few moments, and then ſcud up the ſtream. There ſeems to be a peculiar inſtinct in them, to aim at this very point; for the force of the ſtream on the top of the precipice, is leſs at the bottom, cloſe to the rock than on the ſurface. It is almoſt incredible, the height to which they will leap, they frequently leap near twenty feet. The manner of their doing it is, by bending their tails round, almoſt to their heads; it is then by the ſtrong re-action of their tails againſt the water, that they ſpring ſo much above it.

13. One particular inſtance of the divine care, is obſervable in the turbot. He is not well able to ſwim, eſpecially in ſtormy weather. He muſt then keep at the bottom, and ſtick in the ſand. And for that reaſon he is provided, with a ſkin or membrane which he draws over his eyes, to keep the ſand out of them.

Whales are as many degrees raiſed above other fiſhes in their nature, as they are in their ſize. They reſemble beaſts in their natural ſtructure, and in ſome of their appetites and affections. They have lungs, a midriff, a ſtomach, inteſtines, liver, ſpleen, bladder, and parts of generation like beaſts. Their heart alſo reſembles that of beaſts, driving red and warm blood in circulation through the body.

As theſe animals breathe the air, they cannot bear to be long under water. They are conſtrained, every two or three minutes, to come up to the ſurface to take breath, as well as to ſpout out through their noſtril (for they have but one) the water which they ſucked in while gaping for their prey.

The ſenſes of theſe animals ſeem alſo ſuperior to thoſe of other fiſhes. The eyes of other fiſhes are covered only with that tranſparent ſkin that covers the reſt of the head; but in all the cetaceous kinds, they

are covered by eye-lids as in man. This keeps that organ in a more perfect ſtate, by giving it intervals of relaxation. The other fiſhes, whoſe eyes are very ſtaring, muſt ſee, if for no other reaſon, more feebly, as their organs of ſight are always exerted.

As for hearing, they are furniſhed with the internal inſtruments of the ear, although the external orifice no where appears. It is probable, this orifice may open by ſome canal into the mouth; but this has not as yet been diſcovered.

It is likely, that all animals of the kind can hear, as they certainly utter ſounds to each other. This vocal power would be as needleſs to animals naturally deaf, as glaſſes to a man that was blind.

But it is in the circumſtances in which they continue their kind, that theſe animals ſhew an eminent ſuperiority. Other fiſh depoſit their ſpawn, and leave the ſucceſs to accident; theſe never produce above one young, or two at the moſt; and this the female ſuckles entirely in the manner of quadrupedes, her breaſts being placed as in the human-kind.

In fiſhes of the whale-kind, the tail has a different poſition from what it has in all other fiſhes. For whereas in theſe it is erected perpendicular to the horizon, in them it lies parallel thereto; partly to ſupply the uſe of the hinder pair of fins, which theſe creatures have not, and partly that they may be able to raiſe or depreſs their body at pleaſure. For it being neceſſary they ſhould frequently come to the top of the water, to take in, or let out the air, they are provided with an organ to facilitate their aſcent and deſcent as they have occaſion. And as for turning their bodies in the water, they perform that as birds do; by ſtrongly moving one of their fins, while the other is quieſcent.

The Norway whale is frequently ſixty or ſeventy feet long. His ſhape pretty much reſembles that of a cod; he has a large head, and ſmall eyes in proportion. On the top of the head are two openings, through which he ſpouts out the water (which he takes in, as he breathes) like a large fountain, which makes a violent noiſe.

His

His ſkin is ſmooth and not very thick. The colour of his back is dark and marbled. His belly is white. His throat is very narrow, in proportion to his ſize.—Under his backbone lies a long bladder, which he dilates or contracts as he pleaſes. He rows himſelf with his tail. They copulate after the manner of land animals.

The female brings forth but one or two at a birth, at which time they are nine or ten feet long. They ſuck for ſome time: when they are tired with ſwimming, ſhe carries them between her great fins. Under the ſkin lies the blubber or fat. Its uſual thickneſs is about ſix inches: but about the under lip it is found two or three feet thick. Out of this the oil is extracted. One whale ordinarily yields forty or fifty, ſometimes eighty or ninety hundred weight.

The uſe of blubber ſeems to be, partly to poiſe the body and make it equiponderant to the water; partly to keep the water at a diſtance from the blood, leſt it ſhould be chilled by its immediate contact; and partly to keep the fiſh warm, by reflecting the hot ſteams of the body, and ſo redoubling the heat.

Under the fat is the fleſh of a reddiſh colour. Their general food, is certain ſmall inſects, which float upon the water, in great heaps, and are no larger than flies. But they likewiſe eat various ſorts of ſmall fiſh, particularly herrings, which they drive together in large ſhoals, and then ſwallow vaſt quantities at a time.—The whale commonly goes under the ſhoal; then opens his mouth and ſucks in all he can. Sometimes he ſwallows ſo many, that he is ready to burſt, and ſets up a hideous roar.

But he is far more troubled by a ſlender fiſh about four feet long, which tears great pieces of fleſh out of him. The whale then not only makes a frightful noiſe, but often leaps a conſiderable height. In theſe leaps he ſometimes raiſes himſelf perpendicular above the ſurface of the water, and then plunges himſelf down with ſuch violence, that if his head ſtrikes any of the hidden rocks that are in the ſhallows, he fractures his ſcull, and comes inſtantly floating up dead. So that there is no creature in the world ſo great or ſtrong ſo as to be exempt from calamities!

The whalebone-whale is about ſeventy feet long, and very bulky, having ſcales, and no fins, but only one on each ſide, from five to eight feet long.

The ſpermaceti whale is much of the ſame dimenſions. The ſpermaceti oil lies in a great trunk, four or five feet deep, and ten or twelve feet long, near the whole length, breadth, and depth of the head. It ſeems to be no other than the brain. Not but ſome other parts of the fiſh yield an oil; but not ſo good as that in the trunk. The care of their young is remarkable: while they carry them under water, they often riſe for the benefit of the air. Whenever they are chaſed or wounded, as long as they have ſenſe, and perceive life in their young, they will not leave them, and if in their flying the young one drops off, the dam comes about, and paſſing underneath takes it again.

Whales are gregarious, being ſometimes found a hundred in a ſwarm, and are great travellers. In autumn the whalebone-whales go weſt-ward: in ſpring eaſt-ward again. The ſeveral kind of whales do not mix with each other, but each keep by themſelves.

Their wonderful ſtrength lies chiefly in the tail. A boat has been cut down from the top to the bottom by the tail of a whale, and the clapboards entirely ſplintered, though the gunnel on the top was of tough wood. Another has had the ſtern-poſt, three inches thick, cut off ſmooth without ſo much as ſhattering the boat, or drawing the nails of the boards.

It is commonly ſuppoſed, that all fiſhes are mute, as well as void of hearing. But a late author ſays, there is one kind of whale, that when they are ſtruck roar ſo loud as to be heard two miles. He likewiſe aſſerts, that ſome of them have hearing, as have frogs, ſnakes, and all the lizard-kind, though they have not the uſual outward apparatus of hearing. But they have the auditory paſſage, by which ſound is conveyed, and internal organs, to which the meatus auditorius reaches. This is obſervable in all the whale-kind, and in all fiſhes that have lungs. And whereas ſome have ſuppoſed, that water cannot tranſmit ſound, the contrary of this is now well known. Many experiments have ſhewn, that even a man under water may hear what is ſpoken in the open air.

The

The hippopotamos, or river-horſe, is above ſeventeen feet long from the ſhout, to the inſertion of the tail; above ſeven feet in circumference round the body, and above ſeven feet high: the head is near four feet long, and above nine feet in circumference. The jaws open about two feet wide, and the cutting teeth, of which it hath four in each jaw, are above a foot long.

Its feet reſemble thoſe of the elephant, and are divided into four parts. The tail is ſhort, flat, and pointed; the hide is impenetrable to the blow of a ſabre; the body is covered over with a few ſcattered hairs of a whitiſh colour. The figure of the animal is between that of an ox and a hog, and its cry between the bellowing of the one, and the grunting of the other.

It chiefly reſides at the bottom of the great rivers and lakes of Africa; the Nile, the Niger, and the Zara; there it leads an indolent life, ſeldom diſpoſed for action, except when excited by the calls of hunger. Upon ſuch occaſions, three or four of them are often ſeen at the bottom of a river, forming a kind of line, and ſeizing upon ſuch fiſh as are forced down by the violence of the ſtream. In that element they purſue their prey with great ſwiftneſs and perſeverance; they ſwim with much force, and remain at the bottom for thirty or forty minutes without riſing to take breath. They traverſe the bottom of the ſtream, as if walking upon land. But it often happens, that his fiſhy food is not ſupplied in ſufficient abundance; it is then forced to come upon land, where it is an aukward and unweildly ſtranger; it moves but ſlowly, yet it commits dreadful havoc among the plantations of the helpleſs natives, who ſee their poſſeſſions deſtroyed, without daring to reſiſt their invader. Their chief method is, by lighting fires, ſtriking drums, and raiſing a cry to frighten it back to its favourite element. But if they happen to wound it, it then becomes formidable to all that oppoſe it; overturning whatever it meets. It poſſeſſes the ſame inoffenſive diſpoſition in its favourite element, that it is found to have upon land; it never attacks the mariners in their boats, as they go up or down the ſtream; but ſhould they inadvertently ſtrike

againſt

againſt it, there is much danger of its ſending them, at once, to the bottom, " I have ſeen, ſays a mariner, one of theſe animals open its jaws, and ſeizing a boat between his teeth, at once, bite and ſink it to the bottom. I have ſeen it upon another occaſion, place itſelf under one of our boats, and riſing under it, overſet it with ſix men which were in it; who, however, happily received no other injury." Such is the great ſtrength of this animal: and from hence, probably, the imagination has been willing to match it in combat againſt others more fierce and equally formidable. The crocodile and ſhark have been ſaid to engage with it, and yield an eaſy victory; but as the ſhark is only found at ſea, and the hippopotamos never ventures beyond the mouth of freſh water rivers, it is moſt probable that theſe engagements never occurred; it ſometimes happens, indeed, that the princes of Africa, amuſe themſelves with combats, on their freſh-water lakes, between this and other formidable animals; but whether the rhinoceros or the crocodile are of this number, we have not been particularly informed. If this animal be attacked at land, and finds itſelf incapable of vengeance, from the ſwiftneſs of its enemy, it immediately returns to the river, where it plunges in head foremoſt, and after a ſhort time riſes to the ſurface, loudly bellowing, either to invite or intimidate the enemy; but though the negroes will venture to attack the ſhark, or the crocodile, in their natural element, and their deſtroy them, they are too well apprized of the force of the hippopotamos to engage it; this animal, therefore, continues the uncontrolled maſter of the river, and all others fly from its approach or become an eaſy prey.

As the hippopotamos lives upon fiſh and vegetables, ſo it is probable the fleſh of terreſtrial animals may be equally grateful: the natives of Africa aſſert, that it has often been found to devour children and other creatures that it was able to ſurpriſe upon land; yet as it moves but ſlowly, almoſt every creature, endued with a common ſhare of ſwiftneſs, is able to eſcape it; and this animal, therefore, ſeldom ventures from the river ſide, but when preſſed by the neceſſities of hunger, or of bringing forth its young.

The

The female always comes upon land to bring forth, and it is ſuppoſed that ſhe ſeldom produces above one at a time; upon this occaſion, theſe animals are particularly timorous, and dread the approach of a terreſtrial enemy; the inſtant the parent hears the ſlighteſt noiſe, it daſhes into the ſtream, and the young one is ſeen to follow it with equal alacrity.

The young ones are ſaid to be excellent eating; but the negroes, to whom nothing that has life comes amiſs, find an equal delicacy in the old. Dr. Pocock has ſeen their fleſh ſold in the ſhambles, like beef; and it is ſaid, that their breaſt, in particular, is as delicate eating as veal. Theſe animals are found in great number, and as they produce very faſt, their fleſh might ſupply the countries where they are found, could thoſe barbarous regions produce more expert huntſmen. But this creature, which once was in ſuch plenty at the mouth of the Nile, is now wholly unknown in Lower Egypt, and is no where to be found in that river, except above the cataracts.

One can hardly tell whether to rank him among land or water animals. He ſleeps on land, but paſſes almoſt all the reſt of his time under water. He has to feed under water, yet is the moſt unweildly of all creatures, and cannot ſwim at all. He comes out of the water in an evening to ſleep: and when he goes in again, he walks very deliberately in overhead, and purſues his courſe along the bottom, as eaſy and unconcerned as if it were the open air. The rivers he moſt frequents are very deep, and where they are clear, this affords an aſtoniſhing ſight.

An animal of this ſize and make, muſt be one of the ſtrongeſt in the world. It therefore required from nature no ſwiftneſs, either to avoid purſuit, or to overtake its prey, as it was deſigned to feed chiefly on vegetables. The manner of its feeding on them is this. When he walks into a river, he ſeldom looks about till he is near the middle. Here he ſeeks for the larger water-herbs, particularly for the root of a large water-lilly. People from a boat on the ſurface frequently ſee this. He roots up theſe with his noſe, like a hog, and his mouth and throat being very wide, ſwallows them up in vaſt morſels half chewed.

But

But he has frequently occaſion to breathe: in order to which, when feeding at his eaſe, his cuſtom is, every thirty or forty minutes, to riſe to the ſurface of the water. This he does, by a ſpring from the bottom, made with all his feet at once. Having taken a little freſh air, and looked about him, he drops to the bottom again.

Of all the inhabitants of the deep, thoſe of the ſhark-kind are the moſt voracious. The ſmalleſt of this tribe is not leſs dreaded by greater fiſh, than many that ſeem more powerful; nor do any of them ſeem fearful of attacking animals far above their ſize. But the great white ſhark joins to the moſt amazing rapidity, the ſtrongeſt appetites for miſchief: as he approaches nearly in ſize to the whale, he far ſurpaſſes him in ſtrength and celerity, in the formidable arrangement of his teeth, and his inſatiable deſire of plunder.

The white ſhark is found from twenty to thirty feet long. Some aſſert, that they have ſeen them of four thouſand pounds weight. The mouth is enormouſly wide; as is the throat, and capable of ſwallowing a man with great eaſe. But its furniture of teeth is ſtill more terrible: of theſe there are ſix rows, extremely hard, ſharp-pointed, and of a wedge-like figure. It is aſſerted, there are ſeventy-two in each jaw, one hundred and forty-four in the whole. With theſe the jaws both above and below are planted all over, but he has a power of erecting or depreſſing them at pleaſure. When the ſhark is at reſt, they lie quite flat in the mouth: but when he prepares to ſeize his prey, he erects all this dreadful apparatus, and the animal he ſeizes, dies pierced with a hundred wounds in a moment.

His ſkin is rough, hard, and prickly, being that ſubſtance which covers inſtrument-caſes, called ſhagreen.

No fiſh can ſwim ſo faſt as he; he outſtrips the ſwifteſt ſhips, plays round them, darts out before them, and returns to gaze at the paſſengers. Such amazing powers, with ſuch great appetites for deſtruction, would quickly unpeople even the ocean: but providentially the ſhark's upper jaw projects ſo far above the lower, that he is obliged to turn on one ſide (not on his back, as is generally ſuppoſed) to ſeize his prey. As this

takes

takes ſome ſmall time to perform, the animal purſued often ſeizes that opportunity to eſcape.

Tortoiſes are commonly known to live more than eighty years; and there was one kept in the archbiſhop of Canterbury's garden, at Lambeth, that was remembered above a hundred and twenty. It was at laſt killed by the ſeverity of a froſt, in its winter retreat, which was a heap of ſand, at the bottom of the garden.

The young tortoiſes are generally excluded in about twenty-ſix days. The little animals no ſooner leave the egg than they ſeek for their proviſion, and their ſhell, with which they are covered from the beginning, expands and grows larger with age. As it is compoſed of a variety of pieces, they are capable of extenſion at their ſutures, and the ſhell admits of increaſe in every direction. It is otherwiſe with thoſe animals, whoſe ſhell is compoſed all of one piece, that admits of no increaſe; which, when the tenant is too big for the habitation, muſt burſt the ſhell, and get another. But the covering of the tortoiſe grows larger in proportion as the interior parts expand; in ſome meaſure reſembling the growth of the human ſcull, which is compoſed of a number of bones, increaſing in ſize, in proportion to the quantity of the brain. All tortoiſes, therefore, as they never change their ſhell, muſt have it formed in pieces: and though in ſome theſe marks have not been attended to, yet doubtleſs they are general to the whole tribe.

It is of different magnitudes, according to its different kinds; ſome turtles being not above fifty pounds weight, and ſome above eight hundred.

The great mediterranean turtle is the largeſt of the turtle-kind, with which we are acquainted. It is found from five to eight feet long, and from ſix to nine hundred pounds weight.

All tortoiſes having ſmall and weak feet, are exceeding ſlow in their motions. They have neither tongue nor teeth, nor any offenſive weapon. How then can they take, how can they chew, or in any degree comminute their food? This is well provided for: they break not only ſhells, but ſometimes even ſtones with their lips: which by their exceſſive hardneſs effectually

ſupply

ſupply the want of teeth. But how can they defend themſelves? Abundant proviſion is made for this alſo. Their ſhells more than cover the whole body, and are of ſo firm a texture, that a loaded waggon may go over them, without any injury either to the ſhell or the creature within it.

The blood of tortoiſes is colder than any common ſpring water: yet is the beating of the heart as vigorous as that of any animal, and the arteries as firm as thoſe of any creature.

There is ſomething highly remarkable in the change of tadpoles into frogs; but there is ſtill ſomething more remarkable in the frog-fiſh. Theſe are found in great numbers in the river Surinam. At firſt they are perfect frogs, they are ſpotted with brown, yellow, and green; but are paler on the belly, their hinder feet are webbed, like thoſe of a gooſe, the fore-feet without webs. The firſt change the animal undergoes, is by the growing of a tail. After this the fore-feet decreaſe, and periſh by degrees. The decreaſe of the hinder legs follows, and at laſt the frog is changed into a perfect fiſh.

It may not be unacceptable or unprofitable to thoſe who ſee God even in his loweſt works, to add a ſhort account of a few more inhabitants of the waters.

Flying-fiſh are very rarely a foot long. They have a pretty large, though thin and light head. The mouth is generally open; the body ſmall, roundiſh, and tapering towards the tail; beſides the uſual fins, they have under their necks, three broad and pretty long ones, of a more ſubtle ſtructure, nearly as thin as a fly's wing, but ſtrengthened with rows of bones. On the back part of their neck they have alſo a flying fin, about ſix inches long, quite erect. And lower down the back, there is another ſhorter, but broader. Theſe wings they uſe to eſcape the purſuit of creatures too powerful for them. They riſe ſeveral feet above the water, and fly the length of two or three muſket-ſhot. Then they drop, becauſe their wings are dry, which ſerve them no longer than they are moiſt.

The

The ink-fiſh, as ſome call it, has a ſtill more extraordinary way of eſcaping its purſuers. "I have lately, ſays the Author of the Natural Hiſtory of Norway, procured a dried one, which is two feet long. The body is almoſt round, reſembling a ſmall bag, and is blunt at both ends. But the head is the moſt remarkable part. It has two large eyes, and a mouth like a bird's beak. Above this ſtand eight horns, like a ſtar. Each horn is octangular, and covered with many ſmall, round balls, ſomething larger than a pin's head. On each ſide of the body there are two ſkinny membranes, with which he can cover himſelf all over. The fore-part of the body is quite filled with a black fluid. When it is purſued, it diſcharges this which colours the water all around, and renders it inviſible. This is a wonderful gift of nature, for the preſervation of an animal, otherwiſe utterly helpleſs.

The arboreſcent ſtar-fiſh is another of the curioſities of nature. It is upwards of a foot in diameter, having its mouth in the middle. The figure of the trunk is pentangular, and from the five angles ariſe as many branches, which ſub-divide into ſeveral others, and thoſe again into others, that are leſs, till the laſt are ſcarce thicker than horſe-hairs, and in number above a thouſand. In ſwimming he ſpreads all theſe branches like a net; and when he perceives any prey within them, draws them in again, and ſo takes them with all the dexterity of a fiſherman.

Full as ſurpriſing a creature is the torpedo, a flat fiſh, much like a thorn-back. It is common on the coaſt of Provence, and is eaten without any ill effect. But upon touching it with the finger, the perſon commonly (though not always) feels an unuſual, painful numbneſs, which ſuddenly ſeizes him up to the elbow, and ſometimes up to the ſhoulder. It reſembles, but far exceeds, the pain felt by ſtriking the elbow violently againſt a hard body. But it laſts only a few moments, and gradually wears away. If a man touch it even with a ſtick, he feels a little of it. If he preſſes his hand ſtrongly againſt it, the numbneſs is the leſs. But it is ſo uneaſy as to oblige him, very ſpeedily to let

let it go. Many have attempted to account for this; but ſhould we not rather honeſtly own our ignorance?

The ſea-nettle, ſo called, is another ſtrange production of nature, common, I ſuppoſe, in all the northern ſeas. It generally ſwims on the top of the water, and is throughout ſoft, ſmooth, and tranſparent. It appears to be a lump of ſlime or jelly. But it coheres firmly together, being marked in the middle with a croſs ſomewhat like a flower-de-luce.

Theſe creatures are blue, white, or red, and ſome of them have many branches underneath. Theſe are uſually ſomething larger than the common ſort, and are of a dark red. They all abound with a corroſive poiſon, which if it drop on any part of the body will cauſe a ſmart and an inflammation, much like that produced by nettles. Hence it has its name. However it is no vegetable, but evidently a living creature. For it has ſenſation: it grows, moves to and fro, contracts and extends itſelf. It often picks up and devours ſmall fiſh, and is itſelf devoured by others.

The care of the Creator is obſervable, even in ſo inconſiderable a creature as a limpet, a ſmall ſhell-fiſh, which ſo faſtens itſelf to the rock, that ſcarce any thing can unlooſe its hold.

The fact has long been known. But the manner of its faſtening itſelf, was not underſtood till very lately. Its ſhell approaches to the figure of a cone; the baſe of which is occupied by a large muſcle, which alone has nearly as much fleſh in it, as the whole body of the fiſh. This is not covered by the ſhell, but ſerves the creature equally to move forward or to fix itſelf to the rock. When it is in a ſtate of reſt, which is the common caſe, it applies this muſcle every way round to the ſurface of ſome ſtone, and thereby holds itſelf fixt to it ſo firmly, that it is impoſſible to take it off with the hands. Thoſe who would remove them are obliged to make uſe of a knife for that purpoſe. And even then it is not eaſy: for on whatſoever ſide the blade of the knife attempts to enter, the fiſh immediately fixes its muſcle with double force to the ſtone.

The true cauſe of his adheſion is a viſcous juice, a

kind

kind of glue, thrown out by this muſcle, which though it is not perceptible to the eye, yet it is eaſily perceived by the touch. For if immediately after the removing a limpet from the ſtone, the finger be applied to the place, it is faſtened very ſtrongly to it, by means of the glue left there. But if any wet have come upon the ſtone, ſince the fiſh has been removed, no viſcoſity can be perceived on it, the whole ſubſtance of the glue being immediately diſſolved. This conſideration may lead us to obſerve the great care of nature over all her works. How eminently is it manifeſted in this little fiſh? It was abſolutely neceſſary for its preſervation, that it ſhould have a power of fixing itſelf to the ſtone, or it would have been waſhed away by every wave. And this power is given it, by means of that glue which fixes it ſo firmly. But when it is fixed, how ſhall it be looſed? This is equally neceſſary. For if there be not ſome power in the animal itſelf, to diſſolve this glue, it muſt needs periſh for want of food, when once fixt to a barren ſpot. Water is the proper diſſolvent of this glue. But it cannot be the external water. This is kept at a diſtance, by the cloſe adheſion of the outer rim of the great circular muſcle. And it is needful it ſhould: elſe it would always diſſolve the glue, as ſoon as it was diſcharged. But the under ſurface of the body of the animal is covered all over with ſmall tubercles, moſt of which contain water. When therefore it would move, it has only to diſcharge a ſmall quantity of this water, and the cement immediately diſſolves and ſets it at liberty. The other tubercles doubtleſs contain the viſcous matter. So that when the animal would fix itſelf, it needs only to ſqueeze one ſet of its tubercles, and when it would looſe itſelf, the other.

14. Upon the whole, how natural are the reflections, which a late writer makes on the inhabitants of the waters?

What an abundance of fiſh do the waters produce? In theſe I ſeem to diſcern nothing but a head and a tail. They have neither feet nor hands. Nor have they any neck: ſo that their head cannot be turned at all, any otherwiſe than by turning the whole body.

were

Were I to conſider their figure only, I ſhould think they were deſtitute of all that was neceſſary for the preſervation of their life. But with theſe few outward organs they are more nimble and dexterous, than if they had ſeveral hands and feet. And by the uſe they make of their tail and fins, they are carried along like arrows.

But as almoſt all fiſhes prey upon each other, and cannot ſuſtain their own lives, any otherwiſe than by continually deſtroying thoſe of their own ſpecies, how can the inabitants of the water ſubſiſt? How can many ſpecies eſcape utter deſtruction? God has guarded againſt this, by multiplying them in ſo prodigious a manner. More than three hundred thouſand eggs have been counted in the roe of a ſingle ſalmon. By this means, let them be deſtroyed ever ſo faſt, ſtill their increaſe is equal to their conſumption.

But who can explain how the inhabitants of the ſea enjoy their perfect health, in the midſt of water ſo loaded with ſalt? And by what art is it, that they preſerve even there, a fleſh that has not the leaſt taſte of it?

Why do thoſe which are fitteſt for the uſe of man, come and offer themſelves on our coaſts? While ſo many that would be uſeleſs, if not pernicious, affect remoteneſs from us.

Why do ſeveral of them, in their ſtated ſeaſons, run up into our rivers, and communicate the advantages of the ſea, to ſuch countries as are far diſtant from it? What hand conducts them with ſo much care and goodneſs, but thine, O thou Preſerver of men!

CHAP.

CHAP. IV.

Of REPTILES.

1. *Of their Motion.*
2. *Of Serpents.*
3. *Of their Brain, Stomach, Generation:*
4. *Venom.*
5. *Of ſome particular Sorts of Reptiles.*
6. *Water Lizards often change their Skins:*
7. *Re-production of Parts cut off.*
8. *Of Tape-worms.*
9. *Of Worms that feed on Stones.*

1. NOT far removed from fiſhes are reptiles, ſo named from their creeping, or advancing on the belly. Many ſpecies of them have legs and feet, but very ſmall in proportion to the body. There is a world of contrivance in their motion. The whole body of the earth-worm for inſtance, is a chain of annular muſcles, or rather one continued ſpiral muſcle, the orbicular fibres whereof being contracted, make each ring narrower and longer, by which means it is enabled, like the worm of an augre, to bore its paſſage, into the earth. Its creeping may be explained by a wire, wound on a cylinder. If this is taken off, and one end extended and held faſt, it will bring the other near it. So the worm having ſhot out its body, which is ſpiral, takes hold by its ſmall feet, and ſo brings on the hinder part. Its feet are placed in a four-fold row, the whole length of the worm. With theſe, as ſo many hooks, it faſtens to the earth, or whatever it creeps over, ſometimes this, ſometimes that part of the body, and ſtretches out, or draws after it another.

2. The moſt eminent ſpecies of reptiles are ſerpents, which we may therefore particularly conſider. Their bodies are of a very peculiar make, having a compages of bones articulated together. Here part of the body is applied to the ground, and the other part ſhot forward, which being applied to the ground in its

its turn, brings the other after it. The ſpine of their back variouſly writhed, helps their leaping, (as the joints of the feet in other animals.) They make their leaps by means of the muſcles that extend the folds thereof.

The number of joints in the back-bone are numerous beyond what any one would imagine. In the generality of quadrupeds they amount to not above thirty or forty. In the ſerpent-kind, they amount to a hundred and forty-five from the head to the vent, and twenty-five more from that to the tail. The number of theſe joints muſt give the back-bone a ſurpriſing degree of pliancy: but this is ſtill increaſed by the manner in which each of theſe joints is locked into the other. In men and beaſts the flat ſurfaces of the bones are laid one upon the other, and bound tight by ſinews; but in ſerpents the bones play one within the other like ball and ſocket, ſo that they have a full motion upon each other in every direction. Thus if a man were to form a machine compoſed of ſo many joints as are in the back of a ſerpent, he would find it no eaſy matter to give it ſuch ſtrength and pliancy at the ſame time. The chain of a watch is but a bungling piece of work in compariſon.

Though the number of joints in the back-bone, is great, yet that of the ribs is ſtill greater; for, from the head to the vent, there are two ribs to every joint, which makes their number two hundred and ninety in all. Theſe ribs are furniſhed with muſcles, which being inſerted into the head, run along to the end of the tail, and give the animal great ſtrength and agility.

The ſkin alſo contributes to its motions, being compoſed of a number of ſcales united to each other by a tranſparent membrane, which grows harder as it grows older, until the animal changes it, which is generally done twice a year. This cover then burſts near the head, and the ſerpent creeps from it, by an undulatory motion, in a new ſkin, much more vivid than the former. If the old ſlough be then viewed, every ſcale will be diſtinctly ſeen like a piece of net-work.

There is much geometrical neatneſs in the diſpoſal of the ſerpent's ſcales, for aſſiſting the animal's ſinuous motion. As the edges of the foremoſt ſcales lie over

the

the ends of the following, ſo theſe edges, when the ſcales are erected, which the animal has a power of doing in a ſmall degree, catch in the ground, like the nails in the wheels of a chariot, and ſo promote and facilitate the animal's progreſſive motion. The erecting theſe ſcales is by means of a multitude of diſtinct muſcles, with which each is ſupplied, and one end of which is tacked each to the middle of the foregoing.

Serpents differ very widely as to ſize. The lyboija of Surinam grows to thirty-ſix feet long. The little ſerpent at the Cape of Good Hope is not above three inches, and covers whole ſandy deſerts with its multitudes! This tribe of animals, like that of fiſhes, ſeems to have no bounds put to their growth. Their bones are in a great meaſure cartilaginous; and they are conſequently capable of great extenſion; the older therefore a ſerpent becomes, the larger it grows; and as they live to a great age, they arrive at an enormous ſize. Leguat aſſures us, that he ſaw one at Java, that was fifty feet long.

Vipers are often kept in boxes for ſix or eight months without any food whatever; and there are little ſerpents ſometimes ſent over to Europe, from Grand Cairo, that live for ſeveral years in glaſſes, and never eat at all, nor even ſtain the glaſs with their excrements. Thus the ſerpent tribe unite in themſelves two very oppoſite qualities; wonderful abſtinence, and yet incredible rapacity.

Serpents will ſwim a long time, but they cannot ſtay long under the water, without being ſuffocated. In winter they retire under ſtones, roots of trees, old walls, or any warm, dry ſhelter. Here they ſleep half dead, though with their eyes open, till the returning ſun recals them to life.

3. Their brain little differs from that of fiſhes; but their ſtomach very much. It is like a looſe gut, which runs along, from the jaws quite to the tail. They have likewiſe ſolid ribs and vertebræ, at ſmall diſtances, from the neck to the end of the tail. Hereby they are enabled, to raiſe themſelves up, to ſupport, to writhe themſelves into rings, to ſpring forward, and to ſuck or ſwallow any thing with ſurpriſing force. And their

whole flesh is of so close and firm a texture, that they will live for some time, even after they are cut in pieces. There is nothing more harmless than the common snakes: they are as innocent as flies.

There is a great deal of geometrical nicety in the sinuous motion of serpents. For the assisting herein, the annular scales under their body, are very remarkable, lying cross the belly, contrary to those in the back and the rest of the body. Also the edges of the foremost scales, lie over the edges of the following scales from head to tail. So that when each scale is drawn back, or set a little upright by its muscle, the outer edge of it is raised a little from the body, to lay hold on the earth, and so promote the serpent's motion. But there is another admirable piece of mechanism, that every scale has a distinct muscle, one end of which is fixed to the middle of its scale, the other to the upper edge of the next scale. There is nothing peculiar in the generation of serpents, most of which are oviparous.

4. Vipers and many other serpents have small bags near the root of their teeth, which contain the poison. When they bite, this is squeezed out, by the compression of those bags. If they are taken out of a viper, the liquid they contain mixed with the blood of an animal, causes death. But if taken in by the mouth, it does no harm, losing its efficacy by mixing with other liquids.

A viper has the biggest and flattest head of all the serpent-kind. It is usually half an ell long and an inch thick, with a snout not unlike that of a hog. It has sixteen small teeth in one row; beside two large, sharp, hooked, hollow, transparent teeth, placed at each side of the lower jaw. These convey the poison into the wound, through a long slit. They are flexible, and then only raised, when the viper is going to bite. The roots of them are encompassed with a little bladder, containing a large drop of a yellow insipid juice. This slit is a little below the point of the teeth, which are not hollow to the top. Hence arise all those dreadful symptoms, which frequently end in death. But they are all prevented or removed, by rubbing oil upon the wound.

Vipers

Vipers creep but ſlowly, and never leap or bite, unleſs provoked. They are of a yellowiſh colour, ſpeckled with longiſh brown ſpots. The belly is of the colour of well-poliſhed ſteel. Other ſerpents lay eggs; the female viper only brings forth her young alive, wrapt up in ſkins, which break on the third day, and ſet them at liberty.

The venom of a viper is not mortal to a ſound and robuſt body, though attended with painful ſwellings, violent vomitings, phrenſies, and convulſions. In eight or ten days, the poiſon having run through divers parts of the body, throws itſelf into the ſcrotum, and ſwelling it extremely, cauſes great heat, and much urine very hot and ſharp, by which it is diſcharged, this being the certain criſis of the diſeaſe.

But a ſickly or fearful perſon, bit by a viper ſurely dies, if there be not ſpeedy help. Any one bit, in two or three days weighs almoſt as much more as he did before. Who can account for this?

It is remarkable, that the youngeſt vipers are provided with poiſonous teeth grown to perfection, commenſurate to their bulk; that ſo they may be able to kill their prey and feed themſelves, as ſoon as they are born.

The poiſon of a rattle-ſnake is equally fatal and more ſwift in its operation. For it frequently kills within an hour. The ſnake is from ten to fifteen feet long. But whenever it moves in order to bite, the tail begins to rattle: and that conſiderably loud: ſo that a man if he has preſence of mind, may eaſily get out of its way. When it bites a hare, he is obſerved to lick her all over before he takes her into his mouth: probably, that having moiſtened and ſmoothed her ſkin, he may the more eaſily ſwallow her.

It is very remarkable, that he frequently ſtays under a tree, on which a bird or ſquirrel is hopping about, with his mouth wide open. And the event conſtantly is, the creature in a while drops into it. Sir Hans Sloane thinks, he has wounded it firſt: and that he then waits under the tree, till the poiſon works and the animal drops down into the mouth of its executioner.

But this is not the caſe, as plainly appears, from

what many have been witneſſes of. A ſwallow purſuing his prey in the air, if he caſt his eye on a ſnake beneath him, waiting with his mouth wide open, alters his courſe, and flutters over him in the utmoſt conſternation, till ſinking gradually lower and lower, he at laſt drops into his mouth.

To the ſame purpoſe is the famous experiment of Dr. Sprenger, mentioned in the Hamburgh magazine. He let looſe a mouſe on the ground, at a little diſtance from a common ſnake. It made a few turns, and ſqueaked a little, and then ran directly, into the mouth of the ſnake, which all the while lay ſtill, and without motion.

The rattle-ſnake being leſs nimble than others, would find difficulty in getting its prey, were it not for the ſingular proviſion made, by the rattle in his tail. When he ſees a ſquirrel or bird on a tree, he gets to the bottom, and ſhakes this inſtrument. The creature looking down, ſees the terrible eye of the ſnake bent full upon it. It trembles, and never attempts to eſcape, but keeps its eye upon the deſtroyer, till tired with hopping from bough to bough, it falls down, and is devoured. Indeed the ſame power is in the viper. The field-mice, and other animals, which are its natural food, if they have once ſeen his eyes, never eſcape, but either ſtand ſtill or run into its mouth.

But vipers in general will not eat, after they are under confinement. The viper-catchers throw them together into great bins, where they live many months, though they eat nothing. It is only a female viper, when big with young, that will eat during its confinement. If a mouſe be thrown into the bin, at the bottom of which forty or fifty vipers are crawling, among which one is with young, ſhe alone will meddle with it, and ſhe not immediately. The reſt paſs by it, without any regard, though it be their natural food. But the female, after ſhe has done this ſeveral times, will at length begin to eye it. Yet ſhe paſſes by it again, but ſoon after ſtops ſhort, and holding her head facing that of the mouſe, ſeems ready to dart at it, which however ſhe never does, but opens her mouth, and brandiſhes her tongue. Her eyes having now met thoſe of the mouſe, ſhe never loſes ſight of it more;

but

but they face one another, and the viper advances with her open mouth, nearer and nearer, till without making any leap, ſhe takes in the head, and afterward the whole body.

A common ſnake will avoid a man; but a rattle-ſnake never turns out of the way. His eye has ſomething ſo terrible in it, that there is no looking ſteadfaſtly at him. But he creeps very ſlow, with his head cloſe to the ground, ſo that one may eaſily get out of his way. His leaping is no more than uncoiling himſelf, ſo that a man is in no danger, if he is not within the length of the ſnake. Neither can he do any harm, unleſs he firſt coil, and then uncoil himſelf; but both theſe are done in a moment.

The noiſe they make is not owing (as ſome imagine) to little bones lodged in their tails. But their tail is compoſed of joints that lap over one another, like a lobſter's, and they make that noiſe by ſtriking them one upon another. This is loudeſt in fair weather; in rainy weather they make no noiſe at all. It is remarkable, that whenever a ſingle ſnake rattles, all that are within hearing rattle in like manner.

Of how extremely penetrating a nature is their poiſon? A man provoking one of them to bite the edge of his broad-axe, the colour of the ſteeled part preſently changed: and at the firſt ſtroke he made with it in his work, the diſcoloured part broke out, leaving a gap in the axe.

A gentleman in Virginia has lately given a particular account, of what he felt after being bit by one of them.

"Hearing, ſays he, a bell upon the top of a ſteep hill, which I knew to be on one of the cows of the people where I then quartered, I went right up the hill; but near the top my foot ſlipped, and brought me down upon my knees. I laid my hand on a broad ſtone to ſtay myſelf; I ſuppoſe the ſnake lay on the other ſide, who bit my hand in an inſtant, then ſlid under the ground, and ſounded his rattles. But I ſoon found him, cruſhed his head to pieces with a ſtone, took him up in my left hand, and ran home, ſucking the

the wound on my right hand, and ſpitting out the poiſon. This kept it eaſy; but my tongue and my lips grew ſtiff and numb, as if they were frozen. When I came home, one preſently ripped a fowl open, and bound it upon my hand. This eaſed me a little. I kept my elbow bent and my fingers up, which kept the poiſon from my arm. Another bruiſed ſome turmeric, and bound it round my arm, to keep the poiſon in my hand. This kept my arm eaſy for ſome hours; and my hand, though numb, was not much ſwelled, nor even painful: but about midnight it puffed up on a ſudden, and grew furious, till I ſlit my fingers with a razor. I alſo ſlit the back of my hand, and cupped it, and drew out a quart of ſlimy ſtuff, yet my arm ſwelled. Then I got it tied ſo faſt, that it was almoſt void of feeling. Yet would it work, writhe, jump, and twine like a ſnake, change colour, and be ſpotted. And the ſpots moved to and fro upon my arm, which grew painful at the bone. All things were applied for two days which could be thought on; but without effect, till the aſhes of white-aſh-bark made into a plaiſter with vinegar, drew out the poiſon. We then untied my arm; but within two hours all my right-ſide turned black. Yet it did not ſwell, nor pain me. I bled at the mouth ſoon after, and continued bleeding and feveriſh four days. The pain raged ſtill in my arm, and I was by times delirious for an hour or two. After nine days the fever went away; but my hand and arm were ſpotted like a ſnake all the ſummer. In autumn my arm ſwelled, gathered, and burſt, ſo away went poiſon, ſpots and all.

But the moſt ſurpriſing circumſtance was my dreams. In all ſickneſſes before, theſe were always pleaſant. But now all were horrid. Often I was rolling among old logs; ſometimes I was a white oak cut in pieces. Frequently my feet would be growing into two hickary trees: ſo that it was a terror to me, to think of going to ſleep."

5. It is a wonderful proviſion which is made for thoſe ſnakes, who are inhabitants of the waters. A water-ſnake has no air-bladder like fiſhes: but to make amends for this want, it has a large membranous air-

bag

bag on its back, which it empties or fills with air at pleaſure, by an aperture which it can ſhut ſo cloſe, that the leaſt globule of water cannot enter. By this means it can enlarge or leſſen the bulk of its body, and inhabit any depth of water.

As for the ſerpent of the waters, of which an account is gravely given, by the writer of the Natural Hiſtory of Norway, which he talks of, as being five or ſix hundred yards long, and as rearing his head higher than the main-maſt of a man of war. I preſume it is very nearly related to the craken of the ſame author: a ſea-monſter, to which a whale is but a ſhrimp, larger than twenty men of war put together. And this our writers of magazines and reviews, ſwallow without any difficulty! Is it from the juſt judgment of God, that men who do not believe the Bible, will believe any thing?

The king of all reptiles which are known with any certainty, is the crocodile. There are ſixty-two joints in the back-bone, which, though very cloſely united, have ſufficient play to enable the animal to bend like a bow to the right and the left; ſo that when we hear of perſons eſcaping the creature by turning out of the right line, and of the animal's not being able to wheel after its prey, ſeems to be fabulous. It is likely the crocodile can turn with great eaſe; for the joints of its back are not ſtiffer than thoſe of other animals: and we know by experience, it can wheel about very nimbly for its ſize.

It is probable, that the ſmell of muſk, which all theſe animals exhale, may render them agreeable to the ſavages of that part of Africa. They are often known to take the part of this animal which contains the muſk, and wear it as a perfume about their perſons. Travellers are not agreed in what part of the body their muſk-bags are contained; ſome ſay in the ears; ſome, in the parts of generation; but the moſt probable opinion is, that this muſky ſubſtance is amaſſed in glands under the legs and arms.

The American crocodile, or alligator, is only fifteen or ſixteen feet long. But thoſe bred in Africa, or the

Eaſt-

Eaſt-Indies, are ſaid to be between five and twenty and thirty. It may well be ſaid of him (which cannot be ſaid of the whale) that "his ſcales are his pride:" for on his back, as well as on his head, they are impenetrable as ſteel. No creature dares withſtand him. "He is the king of all the children of pride." And as every female crocodile lays ſome hundreds of eggs at once, they would utterly diſpeople the waters, were it not that the male devours all he can find of them. And ſo diligent is he in his ſearch, that ſcarce one out of a hundred eſcapes him. It is another inſtance of divine mercy, that he cannot bite under water. By this circumſtance, creatures that are able to dive, generally eſcape his ravenous jaws. It is a vulgar error, that he moves the upper jaw: he moves the lower only.

The cameleon (as well as the alligator) is of the lizard-kind. Some in Egypt are twelve inches long; but the Arabian ſeldom exceeds ſix. He has four feet, and a long flat tail, whereby he hangs on trees, as well as by his feet. His ſnout is long, his back ſharp, and grained like ſhagreen. He has no ears, neither does he make or receive any ſound. The tongue is half the length of the animal, round to the tip, which is flat and hollow, ſomewhat like an elephant's trunk. And this he darts out, and draws back with ſurpriſing ſwiftneſs. The great uſe of this is, to catch flies, (which are its proper food, not the air, as is vulgarly thought) by darting it out upon them. Its colour is not always the ſame. One at Paris, when it was in the ſhade, and at reſt, was of a bluiſh grey. In the ſunſhine this changed to a darker grey, and its leſs illumined parts to various colours. When handled or ſtirred, it appeared ſpeckled with dark ſpots bordering upon green. If it was wrapt up a few minutes in a linen cloth, it was ſometimes taken out whitiſh. But it did not take the colour of any other cloth or ſubſtance that encloſed it. So that its aſſuming all the colours it comes near, is a groundleſs imagination.'

The cameleon at London was of ſeveral colours, like a mottled coat. The moſt diſcernable were, a green, a ſandy yellow, and a liver colour. When

ſtirred

ſtirred or warmed it was ſuddenly full of black ſpots, as big as a large pin's head. But when it was quiet, they gradually diſappeared.

There are four ſpecies of cameleons, 1. The Arabian, about the ſize of the green lizard. This is of a whitiſh colour, variegated with reddiſh and yellowiſh ſpots. 2. The Egyptian, which is of a middle hue, between a whitiſh and a faint green. 3. The Mexican. And 4. A kind which has been frequently ſhewn in Europe, and differs from all the reſt. His head is large; but he alters his body at pleaſure, inflating it more or leſs: and not only his body, but his legs and tail. This is peculiar to him. The body thus puffed up, will remain ſo two hours. But it is inſenſibly ſinking all the time. It can continue a long time in either of theſe ſtates; but is generally uninflated. It then looks miſerably lank and lean: its back-bone may be ſeen perfectly; its ribs counted, and even the tendons of the feet diſtinctly ſeen through the ſkin.

Its mouth is furniſhed with continued, denticulated bones; but it does not appear what uſe they are of, ſince it preys on flies, and ſwallows them whole, unleſs for holding a ſtick in its mouth croſs-ways; which according to Ælian, he frequently does, to prevent being ſwallowed by ſerpents.

The ſtructure and motion of his eyes are ſurpriſing. They appear to be large ſpheres, of which one half ſtands out of the head, and is covered with a thick ſkin, perforated with a ſmall hole at top. Through this is ſeen a very vivid and bright purple, ſurrounded with a yellow iris. This hole is a longitudinal ſlit, which he opens more or leſs at pleaſure. The motion of his eyes is not leſs ſingular. It can turn them, ſo as to ſee either forward, backward, or on either ſide, without moving the head at all, which is fixt to the ſhoulders. And he can give one eye all theſe motions, while the other is perfectly ſtill. Each foot has five toes, all of one ſide, two behind and three before. He moves very ſlowly on the ground, but on trees more eaſily. Its tail is then its ſafety, as it twiſts it round the branches, when in any danger of falling.

But how can ſo ſlow a creature catch the moſt nimble ſorts of inſects? What nature has denied it in agi-

lity, is abundantly ſupplied by other means. Its ſlow, and eaſy motion renders it but little ſuſpected at a diſtance. And when it comes within a proper ſpace of its object, it ſtretches out its tail, poiſes its body, and fixes itſelf, ſo as ſeldom to meet with a diſappointment. When all is ready, it uncoils its long, ſlender tongue, and darts it ſo ſwift as ſcarce ever to miſs its prey.

The common colour of the cameleons in Smyrna is green, toward the belly inclining to a yellow. But thoſe in the ruins of the caſtle are greyiſh, like the ſtones among which they breed. One of them, having been kept in a napkin, appeared whitiſh; but it never changed to red or blue, though wrapt in cloth of thoſe colours for ſeveral hours together. On being handled or diſturbed, it became ſtained with dark ſpots, bordering on green. Sometimes from a green all over, it became full of black ſpots; ſometimes when it appeared black, green ſpots ſuddenly appeared. So far is it from being true, that it changed its colour, according to every object near it. Nor could we perceive this change to be any fixed law, it rather ſeemed ſpontaneous. This only was conſtant; being placed on green, it became green; being on the earth, it changed to the colour of earth.

Another uncommon creature of the lizard-kind is a ſalamander. This is ſuppoſed to live in fire; but without any ground. It is indeed generally found in the chinks of glaſs-houſes, or near furnaces, where the heat is ſo great, that no other animal could endure it, without being deſtroyed in a few minutes. Some years ago, the trial was made by ſeveral gentlemen, whether it could really live in fire. Some charcoal was kindled, and the animal laid upon the burning coals. Immediately it emitted a blackiſh liquor, which entirely quenched them. They lighted more coals, and laid it upon them. It quenched them a ſecond time in the ſame manner. But being preſently laid on a freſh fire, it was in a ſhort time burnt to aſhes.

In many parts of Lower Egypt, there is a kind of lizard termed oocaral. It reſembles a crocodile, only that it is but three or four feet long, and lives wholly on

on the land. As it is exceeding fond of the milk of ewes and ſhe-goats, it makes uſe of a remarkable expedient. It twiſts its long tail round the leg of the ewe or goat, and ſo ſucks her at his leiſure.

In moſt parts of Italy there are ſwarms of lizards, eſpecially of the green kind. In the ſpring, hundreds of them are ſeen, baſking on the roofs, and crawling up and down the walls of houſes. They are very nimble, and have a bright ſleek ſkin, and beautiful eyes, but are entirely harmleſs. The ſcorpions are not ſo; they harbour not only in old walls and under ſtones, but in every part of the houſe, eſpecially the beds; and if touched, immediately ſting. The ſting of an Apulian ſcorpion, has the ſame effect with the bite of a tarantula. And it requires the ſame method of cure; only by different inſtruments, the flute and bagpipe in particular, with the briſk beat of a drum. But the common remedy againſt the ſting of a ſcorpion is, to bruiſe the animal, and bind it on the wound.

6. With regard to water-lizards, commonly called newts, which moſt people ſuppoſe to be venomous, they are harmleſs as land-lizards, and are found in ſummer, in moſt ſhallow, ſtanding waters. One who kept ſeveral of them in glaſs jars for many months obſerves, in reſpect of that odd circumſtance, caſting their ſkins, they do this every fortnight or three weeks. A day or two before the change, the animal appears more ſluggiſh than uſual, and takes no notice of its food, which at other times it devours greedily. The ſkin in ſome parts appears looſe, and not of ſo lively a colour as before. It begins this work, by looſening with its fore-feet, the ſkin about its jaws, puſhing it forward gently and gradually both above and below the head, till it can ſlip out firſt one leg and then the other. Then it thruſts the ſkin backward as far as thoſe legs can reach. Next it rubs itſelf againſt pebbles, gravel, or whatever elſe it can meet with, till more than half the body is freed from the ſkin; which then appears doubled back, covering the hinder part of the body and tail. Then turning its head round to meet its tail, it takes hold of the ſkin with its mouth, and ſetting his feet thereon, by degrees pulls it off, drawing

the

the hind-legs out, as it did the fore-legs. If you then examine the ſkin, it will be found inſide outward, but without the leaſt hole or breach, the part which covered the hind legs ſeeming like gloves turned inſide out, though entirely perfect and unbroken. They do not however put off the coverings of their eyes, as moſt kinds of ſnakes do; for the ſkin of the newt has always two holes, at the places where the eyes have been. When the ſkin is off, if it be not ſoon taken away, the creature ſwallows it whole.

Many creatures of different kinds, put off their ſkins or ſhells at certain periods, and if we may gueſs at other ſhell-fiſh by the freſh water ſhrimps, their ſhells are put off without any breach but one, lengthways in the middle of the belly-part, through which the body, tail, and claws are pulled out, and the ſhell left in a manner whole. In the inſect-tribe, the changes of caterpillars are well known. The ſpider throws off its ſkin as frequently, getting out of it by a rupture underneath, and leaving every claw entire. And even the horny covering of his forceps. Even the mite caſts its ſkin at ſeveral ſhort periods, and nearly in the ſame manner.

A particular ſpecies of water-lizards, Abbe Spallanzani terms an aquatic ſalamander. Yet he obſerves, this cannot bear any great degree either of heat or cold. But the moſt remarkable circumſtance relating to it is, that let its tail, legs, or even jaws be cut away, and in a ſhort time they are reproduced. The tail, beſide a complete apparatus of nerves, muſcles, glands, arteries and veins, has vertebre of real bone. And their legs do not differ from thoſe of the moſt perfect animals, in the number of bones, whereof they are compoſed.

7. Now when the legs and tail of this animal are taken away, new vertebre, new bones are produced: a phenomenon as wonderful as any hitherto known. This takes place in every known ſpecies of ſalamanders, at any period of their life, on the earth or in the water; and let the length of the divided parts be greater or leſs. Nor do the conſtituent parts of the new tail

differ

differ from thoſe of the part that was cut, either in number, ſtructure, or connexion. But a whole year is ſcarce ſufficient to render the new part equal to that which was cut off. Indeed the regenerating power ceaſes during the winter half year.

When the part reproduced is cut off, it is ſucceeded by another, which proceeds in the ſame manner as the former, and this a ſecond, a third, or fourth time: the ſalamander ſtill forming new parts by the ſame unalterable laws.

There are in the legs of a ſalamander ninety and nine bones. In the four regenerated legs there is the ſame number. The form and internal ſtructure of the reproduced bones, and of the natural, are the ſame. But the colour of the new bones is ſomewhat different, and their ſubſtance more tender. And all theſe parts are reproduced in the ſame manner and at the ſame time, whether the creature is fed, or kept faſting.

When their jaws are cut off, the ſame thing happens. New bones are reproduced, new teeth, new cartilages, veins and arteries. From the wonderful reproduction of ſo many parts in this, may we not extend our inquiry to other animals of equally complicated ſtructure? Let us inquire firſt concerning tadpoles. If the whole of their tails be cut off, they ſink to the bottom of the water, and periſh. But if part only, they ſoon recover it. In one ſummer's day the reproduction makes a rapid progreſs in young tadpoles. And in a ſhort time, the new part of the tail and the old together, equal the tail of others born at the ſame time. A ſecond, third, and fourth reproduction conſtantly follows, upon a ſecond, third, or fourth ſection. Nay, ſucceſſive regenerations never fail, as long as the tadpole keeps its tail.

If no nouriſhment is given tadpoles, they do not grow, nor are the membranes of the infant ſtate caſt off. Yet the tails cut off, will be reproduced nearly in the ſame time.

If the head of an earth-worm be cut off, a new head is reproduced. Nay, if both the head and tail are cut off from the middle part, both of them are reproduced.

duced. Nor is this regenerating power ſoon exhauſted. A ſecond reproduction being cut off, is ſucceeded by a third, this by a fourth, that by a fifth, and ſo on.

The ſame thing takes place in another kind of worm, little known, which the Abbe calls an aquatic boat-worm. It is compoſed of rings like the earth-worm, which it ſhortens or lengthens at pleaſure, and ſo moves from place to place. Toward the head it is as large as the largeſt gooſe-quill, and its length is about a ſpan. It lives in ſhallow, clear water, either ſtagnating or flowing gently, fixing its fore part in the mud, whence it is nouriſhed. The back part reaches the top of the water, and being ſtretched and hollowed, forms a kind of boat on the ſurface. Its ſides riſe above the water, ſo that none gets in. But on the leaſt agitation of the water, the inſect immediately ſhuts up his boat, and retires into the mud. When the motion is over, he again thruſts his tail out of the water, and makes his boat afreſh, which remains entire till he is diſturbed again. And this he does not fail to make, though the mud is removed, and he left with little water. It ſeems the organs of reſpiration are placed in this part, as they are in various ſorts of aquatic animals.

Theſe worms are quicker in their reproduction than earth-worms. They more eaſily recover their heads, as well as tails, and this power exerts itſelf throughout the whole year.

The caſe of the ſnail may ſeem ſtill more ſtrange. It can firſt, reproduce its horns. After they have been cut off, the trunk becomes like a ſmall knob, whence ſprings a black point, which is the eye. The trunk then increaſes in length and ſize, till it equals the former horn.

If the head be cut off, a new one ſucceeds; but in a ſingular manner. If a worm's head be cut off, the reproduction is an entire organic body, that is, a part in miniature exactly ſimilar to that which was cut off. But what appears on the trunk of a ſnail, is not an entire organic body, containing in miniature all the parts of the head which were cut off: but theſe parts

grow

grow piece by piece at different intervals, and require time to unite and conſolidate into one maſs, reſembling the original pattern. For inſtance. Sometimes the reproduction is like a round, ſmall body, containing the primary parts of the two lips, and of the ſmall horns, which are united to the mouth, and to the new-formed teeth. This round body is placed on the centre of the trunk. The large horns and the fore-part of the ſnail, which in the entire animal are contiguous to the head, are wanting. Another trunk ſhews the larger horn on the right ſide, more than a tenth of an inch long, already provided with its eye. Under this, at ſome diſtance, the firſt lineaments of the lip appear. In a third ſnail ariſe three horns, two of which are of their natural length, while the third is but juſt above the ſkin. Some ſhew nothing but the trunk, without any ſign of reproduction, although the head was taken off at the ſame time with that of the others, from which came forth ſuch a number and variety of organs: on the contrary, in ſome ſnails, there is no difference between the old and the new head: only there is an aſh-coloured line, pointing out exactly where the head was cut off.

That earth-worms feed upon earth, will be put beyond diſpute, if any one is at the pains to examine the little curled heaps of dung, which are ejected out of their holes. But it is in all probability, not pure earth, but ſuch as is made of leaves, roots, and plants, when gradually rotted and mouldered away. And what makes this the more probable, is, that they are obſerved to drag the leaves of trees into their holes.

8. Both the whole tape-worm, and every part of it ſeems to be a complete animal. In every joint there is a mouth for receiving food, and doubtleſs organs for digeſting it. Single joints, as well as larger pieces, are frequently voided alive. All thoſe pieces are almoſt equally turgid with chyle. Now it is not probable, that a ſingle worm, ſhould in voiding, be broke in ſo many pieces: and had it been done ſometime before, they would be emaciated. There ſeems then to be an analogy, between this jointed worm and knotted graſs; each joint of which is a complete plant, and propa-

gates

gates itſelf. It is indeed a zoophyton, a plant-animal, bred in animal bodies: ſince ſo large and frequent detruncations, do not deſtroy the life of it.

9. Not only vegetables and animals have their reſpective inſects, to which they afford food as well as habitation, but ſtones themſelves. Thoſe kind of worms, called lithophagi, are a proof of this. One might think it incredible, that theſe little creatures ſhould ſubſiſt by gnawing ſtones. And yet nothing is more certain, theſe worm-eaten ſtones being found almoſt every where. Theſe are generally lime-ſtones. Grit and free-ſtone are ſeldom eaten in this manner. Yet there is an ancient wall of free-ſtone in the Benedictine-abbey at Caen in Normandy, ſo eaten with worms, that one may put one's hands into many of the cavities. The worms are covered with a greeniſh ſhell, having flat heads, a wide mouth, and four black jaws. And they lay their eggs in thoſe cavities, which they gnaw in the ſtone.

One more reptile we may examine a little more minutely, in which the wiſdom of God is not a little diſplayed. It is a common leech. When this is at reſt, its upper lip forms a regular ſemicircle. When he moves, this ſemicircle becomes two oblique lines, the junction of which makes an angle, which he applies to whatever he would fix himſelf to. The two lips then make a ſort of hollow. Both theſe and its mouth are made of ſo ſupple fibres, that they take the figure of the part they are applied to, and fix perfectly cloſe to it.

The wounds it makes are not punctures, but three cuts made like three rays, which uniting in a centre make equal angles with each other. They appear as if made by a fine lancet. They are indeed made by three rows of fine and ſharp teeth, which the microſcope ſhews to be placed along the middle of a ſtrong muſcle. When the mouth has ſeized on any part, the muſcle exerts its action, and ſtrikes in all the teeth at once.

Between the mouth and the ſtomach there is a ſmall ſpace, in which are two different arrangements of fibres.

fibres. The one ſet are flat and plain; the others are circular. The former contracting at length, enlarge the capacity of the throat; and the circular ones determine the blood toward the ſtomach, by contracting it when the blood is received. Hence it paſſes into a kind of membraneous ſack, which ſerves the animal both for ſtomach and inteſtines. This takes up the greateſt part of its body. On each ſide of this long canal there is a number of little bags. Theſe being filled with blood, ſwell out the body of the animal to a large ſize. Here it remains for many months, and ſerves the creature for nouriſhment. If any thing is excreted, it can be only by inſenſible perſpiration, ſince the creature has no anus, nor any aperture which can ſupply the place of one.

Frogs change their ſkins every eight days. Toads, as well as frogs, are harmleſs, defenceleſs creatures, and their greateſt crime is their uglineſs.

Newly generated frogs, which fall to the bottom, remain there the whole day; but having lengthened themſelves a little, (for at firſt they are doubled up) they mount to the mucus which they had quitted, and feed upon it with great vivacity. The next day they acquire their tadpole form. In three days more they have little fringes, that ſerve as fins beneath the head, and theſe, four days after aſſume a more perfect form. It is then they feed greedily upon the pond-weed; and leaving their former food, on this they continue to ſubſiſt, till they arrive at maturity. When they come to be ninety-two days old, two ſmall feet begin to ſprout near the tail; and the head appears to be ſeparate from the body. The next day the legs are conſiderably enlarged; four days after they refuſe all vegetable food; their mouth appears furniſhed with teeth; and their hinder legs are completely formed. In two days more the arms are completely produced, and now the frog is every way perfect, except that it ſtill continues to carry the tail. In this odd ſituation the animal, reſembling at once both a frog and a lizard, is ſeen frequently riſing to the ſurface, not to take food, but to breathe. In this ſtate it continues for ſix or eight hours,

hours, and then the tail dropping off, the animal appears in its perfect form.

Thus the frog, in leſs than a day, having changed its figure, changes its appetites alſo. So extraordinary is this transformation, that the food it fed upon ſo greedily but a few days before, is now utterly rejected. It would even ſtarve, if ſupplied with no other. As ſoon as the animal acquires its perfect ſtate, it becomes carnivorous, and lives entirely upon worms and inſects. But as the water cannot ſupply theſe, it is obliged to quit its native element, and ſeek for food upon land, where it lives by hunting worms, and taking inſects by ſurpriſe.

" Concerning the toad, ſays Mr. Arocott, that lived with us ſo many years, and was ſo great a favourite, the greateſt curioſity was its being ſo remarkably tame; it had frequented ſome ſteps before our hall-door, ſome years before my acquaintance commenced with it, and had been admired by my father for its ſize (being the largeſt I ever met with) who conſtantly paid it a viſit every evening. I knew it myſelf above thirty years: and by conſtantly feeding it, brought it to be ſo tame that it always came to the candle and looked up, as if expecting to be taken up and brought upon the table, where I always fed it with inſects of all ſorts. It would follow them, and when within a proper diſtance, would fix its eyes, and remain motionleſs for near a quarter of a minute, as if preparing for the ſtroke, which was an inſtantaneous throwing its tongue at a great diſtance upon the inſect, which ſtuck to the tip, by a glutinous matter. The motion is quicker than the eye can follow. I cannot ſay how long my father had been acquainted with the toad before I knew it; but when I was firſt acquainted with it, he uſed to mention it as the old toad. I have known it for thirty-ſix years. This toad made its appearance as ſoon as the warm weather came, and retired to ſome dry bank to repoſe till ſpring. When we new-laid the ſteps, I had two holes made in the third ſtep, on each ſide, with an hollow of more than a yard long; in which I imagined it ſlept, as it came from thence at its firſt appearance. It was ſeldom provoked. Neither that toad, nor the multitudes I have ſeen tormented with great cruelty,

ever ſhewed the leaſt deſire of revenge. In the heat of the day toads come to the mouth of their hole; I believe for air. I once, from my parlour window, obſerved a large toad I had on the bank of a bowling-green, about twelve at noon, in a very hot day, very buſy and active upon the graſs. So uncommon an appearance made me go out to ſee what it was; when I found an innumerable ſwarm of winged ants had dropped round his hole, which temptation was irreſiſtible. Had it not been for a tame raven, I make no doubt but it would have been now living. This bird one day ſeeing it at the mouth of its hole, pulled it out, and although I reſcued it, pulled out one eye, and hurt it ſo, that notwithſtanding it lived a twelvemonth, it never enjoyed itſelf, and had a difficulty of taking its food, miſſing the mark for want of its eye."

All toads are torpid and unvenomous, and ſeek the darkeſt retreats, not from the malignity of their nature, but the multitude of their enemies.

CONTENTS

CONTENTS

OF THE

FIRST VOLUME.

THE INTRODUCTION.

Of the gradual Improvement of Natural Philoſophy.

Page

1. The order obſerved in this treatiſe - 10
2. The method of philoſophizing among the Hebrews and Egyptians - - ib.
3. Among the Greeks—The philoſophy of Pythagoras, Plato, Ariſtotle - - ib.
4. The different method purſued by the four Greek ſects - - - 11
5. The philoſophy of the ſchoolmen - ib.
6. The revival of philoſophy by Lord Bacon ib.
7. Greatly promoted by philoſophical ſocieties 12
8. The improvement made in every branch of it: in anatomy; the diſcovery of the circulation of the blood, of the lacteal veins, and the thoracic duct - - ib.
9. Of the generation of all animals from eggs ib.
10. Of the transfuſion of blood - - ib.
11. Diſeaſes themſelves and the operations of medicines give occaſion for farther diſcoveries 13
12. Many anatomical diſcoveries have been made by microſcopes - - ib.
13. Many, with regard to brutes, particularly fiſhes and inſects - - - ib.

14. Many

Page

14. Many likewiſe, with regard to plants, ſtones, metals and minerals - - 14
15. Great improvements from the art of chemiſtry - - - ib.
16. Diſcoveries concerning the loadſtone - ib.
17. Concerning glaſs and burning-glaſſes - ib.
18. The nature of the air is more accurately diſcovered by means of the barometer, the thermometer, and the air-pump - ib.
19. Diſcoveries relating to water - - 15
20. Diſcoveries which ſhew the nature of fire: of gunpowder, phoſphorus, aurum fulminans ib.
21. Of the earth, and the chief ſyſtems of the univerſe - - - - ib.
22. Of the ſun, the planets and their ſatellites 16
23. Of the cauſes of natural bodies - ib.
24. Of ſpirits and divine things - ib.

PART THE FIRST.

Of MAN.

CHAP. I. *Of the Structure of the Human Body.* 17

1. The ſimilar, ſolid parts - - 19
2. A fibre - - ib.
3. The cellular membrane - - 21
4. A bone - - - 23
5. A cartilage - - - 26
6. A membrane - - 27
7. An artery - - - ib.
8. A vein - - - 29
9. The lymphatic veſſels, and their uſe - 30
10. A nerve - - - ib.
11. The fleſh - - ib.
12. A gland - - - ib.
13. A muſcle - - - 31
14. The cuticle and ſkin - - 32
A boy with a dappled ſkin - - ib.
15. The fat - - - 36
16. The panniculus carnoſus - - 37
17. The diſſimilar parts; in particular the head, cerebrum, cerebellum, medulla oblongata ib.

18. The

		Page
18.	The pia and dura mater	38
19.	The brain	ib.
20.	The origin of the nerves	ib.
21.	The pineal gland	39
22.	The guards of the eyes	41
23.	The muſcles of the eye; the tunica adnata, the ſtructure of the eye	ib.
24.	The coats of the eye	42
25.	The humours of the eye	43
26.	Peculiarities relative to the eyes; help for decayed ſight; account of a perſon couched	47
27.	Queries concerning the eyes	49
28.	The external parts of the ear	ib.
	The internal, particularly the drum	50
29.	The bones, paſſages, windows, labyrinth	ib.
30.	The noſtrils	52
31.	Of the tongue	53
	A perſon ſpeaking without a tongue	54
	Perſons deaf and dumb taught to ſpeak	ib.
	Dumbneſs ſuddenly removed	55
	Of the teeth	ib.
32.	The palate	56
33.	The uvula, tonſils, and wind-pipe	57
34.	The hair	58
	Hair turned white through fear and grief	ib.
35.	The heart	60
36.	The pericardium	61
37.	The lungs	62
38.	The thorax, intercoſtal muſcles, diaphragm	65
39.	The pleura and mediaſtinum	66
40.	The external parts of the middle cavity	ib.
	An old woman giving ſuck	67
41.	The ſtomach	ib.
42.	The inteſtines and meſentery	69
43.	The lacteal veins	70
44.	The omentum, peritoneum, pancreas	ib.
45.	The liver, gall-bladder, and ducts	71
46.	The ſpleen	ib.
47.	The kidneys, ureters, bladder	ib.
48.	The hands	72
	Account of a man without arms	ib.
49.	The thighs, feet, and legs	73

Page
50. The animal ſpirits - - 73
51. Secretion of the other fluids - - 74
52. The blood - - - ib.
53. What are the firſt elements of the body 77
54. Reflections - - - 78

CHAP. II.

Of the Natural State of the Human Body.

1. What the natural ſtate of the body means 99
2. Of the circulation of the blood - ib.
3. Of reſpiration - - 102
4. Of chylification - - 105
5. Of nutrition - - ib.
Uncommon inſtances of the utility of abſtinence - - - 106
6. Of the ſenſes - - 108
7. Of the ſight - - ib.
8. The hearing - - ib.
9. The ſmelling - - - 109
10. The taſting - - ib.
11. The feeling - - ib.
12. Of hunger and thirſt - - ib.
13. Of ſleep - - - 110
14. Of local motion - - 113
15. Of the voluntary and involuntary motions ib.
16. Of the ſtature of man - - 114
17. Of the age of man - - 115

CHAP. III,

Of the Preternatural State of the Human Body.

1. What the preternatural ſtate of the body is 116
2. The variety of diſeaſes - - ib.
3. Reduced to three claſſes: thoſe of the ſolids 117
4. Thoſe of the fluids, particularly the blood 118
5. Thoſe of the animal ſpirits - - ib.
6. The remote cauſes of diſeaſes - 119
7. Of fevers - - ib.
8. The way to preſerve health - 120
9. Of life and death - - 121

CHAP. IV.

Of the Soul, and of the Origin of Man.

Page
1. There is ſomething in man, which perceives the various motions of the body - 131
2. The perception is ſometimes continued and recalled - - - ib.
3. We know ſome things in a more ſublime manner - - - 132
4. There is ſomething in us which has an appetite to ſenſual things - - ib.
5. And another appetite, which is often contrary to this - - - - ib.
6. How philoſophers account for the direction of our bodily motions - - ib.
7. For the external ſenſes - - - ib.
8. The imagination and memory - 133
9. The underſtanding, will, and affections - ib.
10. This may be ſo, or not - - ib.
11. Of the immortality of the ſoul - ib.
12. Of the union of the ſoul and body - 134
13. Reaſon cannot diſcover the origin of man ib.
14. The ſcriptural account of it - - ib.
15. Of the production of the ſoul - 135
16. Of the generation of the body - - ib.

PART THE SECOND.

Of BRUTES.

CHAP. I. *Of Beaſts.*

1. The general difference of men and beaſts as to the ſtructure and poſture of the body 143
2. Their agreement - - 145
3. Their agreement and diſagreement as to the head and brain - - - ib.
4. The heart and lungs - - 146
5. The eyes - - - 147
6. The ears, noſe, and teeth - - 149
7. The wind-pipe - - - 151

8. The

Page
8. The vegetative and ſenſitive motions in brutes 151
9. Of the ſoul of brutes - - ib.
10. Of ſome particular ſorts of beaſts 152
Of the elephant - - ib.
Of the rhinoceros - - 156
Of the camel - - 157
Of the dromedary - - 158
Of the lamas of Peru - - ib.
Of the caſtor or beaver - 159
Of the ſhammoy - - 161
Of the roe-buck - - - 162
Of the rein-deer - - 164
Of the aſs: its properties and utility 165
Of the mule - - 166
Of the zebra - - 167
Of the ſquirrel - - 169
Of the marmot - - 170
Of the hedge-hog - - 171
Of the pangolin - - 172
Of the armadillo - - 173
Of animals of the monkey-kind 174
Of the chimpanaze - - - 175
Surpriſing aſſembly of monkies 176
Of the opoſſum - - ib.
Of the ichneumon - - 177
Of the jackal - - 178
Of the ſable mice - - 179
Of the glutton - - 180
Of the ſloth - - - 181
Of the falling off of the horns of beaſts 183
11. Some general reflections - - 184

CHAP. II.

Of Birds.

1. Some general remarks - 188
2. Of their motion - 194

		Page
3.	Of their brain - -	199
4.	Of their organs of ſenſe - -	200
5.	Of their lungs - -	202
6.	Of their ſtomach and bladder -	206
7.	Of the generation of birds -	ib.
8.	Of ſome particular ſorts of birds -	215
	Of the largeſt of birds, the cuntor of Peru	ib.
	Of the ſmalleſt, the humming bird	ib.
	Of vultures: the ſingular ſervice they are of in Egypt - -	217
	Their uſes in America - -	ib.
	Of the rooks: their peculiar modes, or ſyſtems - - -	ib.
	Of the magpie: its peculiar degrees of inſtinct - - -	219
	Of the wood-pecker - -	220
	Of the bird of paradiſe - -	221
	Of the American mock-bird: its uncommon properties - -	222
	Of the crane - -	ib.
	Of the ſtork - -	223
	Remarkable adventure of a tame ſtork at the univerſity of Tubingen -	224
	Of the pelican: its ſingular conſtruction and properties - -	ib.
	Of the albatroſs, one of the largeſt and moſt formidable birds in America	226
	Of the ſwan: its peculiarities and longevity. - -	227
	Of the gooſe, and wild gooſe -	ib.
	Of the Soland gooſe -	228
	Of a couple of remarkable eagles, and a couple of ravens, in the Iſle of Rona, one of the Scotch weſtern iſles -	229
	Of the down-bird in Iceland -	230
	Of the bat - -	ib.
	Of the king-fiſher - -	231
9.	General reflections - -	235

CHAP.

Page.

CHAP. III.

Of Fiſhes.

1. The number of fiſh - - 241
2. Their covering - - ib.
3. Their brain - - - ib.
4. Their organs of ſenſe - - 242
5. Gills, or lungs - - 243
6. The heart - - - 245
7. The air-bladder - - ib.
8. The ſtomach - - ib.
9. The fins - - 247
10. Experiments on fiſh - - 248
11. Of ſhell-fiſh - - - 250

Of the re-production of the ſhells of ſome fiſh - - - ib.

Of the extraordinary manner in which lobſters and crabs change their ſhells ib.

The remarkable difference of the land crabs on the Caribbee Iſlands - 254

The ſurpriſing regularity of their deſcent from the mountains to the ſea ib.

Of the ſoldier crab - - 256

Of crabs eyes - 257

Of turbinated fiſh, of the ſnail kind ib.

Of the oyſter - - 260

The remarkable movings and operations of the ſcallop - - ib.

Of the razor-ſhell - - ib.

Of multivalve ſhell-fiſh - - 261

Of the ſea-urchin - - ib.

Of the acorn ſhell-fiſh, the thumb-footed ſhell-fiſh, and the imaginary barnacle 262

Of the murex, which gives the Tyrian purple - - 263

Of pearl muſcles - - ib.

The peculiarities of muſcles in general 264

Page

In Port Mahon harbour muſcles are found in ſtones of immenſe magnitude 265
Of the bollani, which are found to live in large ſtones in the Adriatic ſea ib.
Of other ſhell-fiſh, found in Toulon harbour, and on the coaſt of Ancona ib.
Of the Pholades bollani, who buries itſelf in the hardeſt rock - ib.
Of the animal flower in Barbadoes: its peculiarities, as it ſeems an aquatic ſenſitive plant - - - 267
12. Of the generation of fiſhes - 268
The manner of ſea-tortoiſes laying their eggs ib.
Uncommon circumſtances attending the generation of ſoles - - ib.
Of the coming of herrings, cod, and other fiſh, in ſhoals, at certain ſeaſons of the year - - 269
Of the coming of ſhoals of mackrel, and the reaſons for their coming 270
Of the tunnies, which comes in ſhoals to the coaſts of Provence and Languedoc 271
Of the ſhoals of pilchards - 272
Of the ſhoals of ſalmon - ib.
Remarkable ſalmon-leap near Dublin ib.
13. Of ſome particular ſorts of fiſhes 273
Peculiar circumſtances of the turbot ib.
Of whales - - ib.
Their ſingular manner of propagation 274
Of the Norway whale - - ib.
The uſe of blubber: their method of feeding - - - 275
Of the whale-bone whale - 276
Of the ſpermaceti whale - ib.
The wonderful ſtrength of the tails of whales - - ib.
Of the hippopotamos, or river horſe 277
His uncommon depredations on land ib.
The female always brings forth on land 279
They always ſleep on land - ib.
Of ſharks - - - 280

Of

Page

Of the white ſhark: its amazing ſwiftneſs, and number of teeth - - 280
Of tortoiſes - - 281
The great Mediterranean turtle - ib.
Of the frog-fiſh of Surinam - 282
Of flying-fiſh - - ib.
Of the ink-fiſh: its ſingular properties 283
Of the Aboreſcent ſtar-fiſh - ib.
Of the torpedo, much like a thorn-back ib.
Of the ſea-nettle, a ſtrange production of nature - - - 284
The amazing peculiarities of the limpet ib.
14. General reflections - - 285

CHAP. IV. *Of Reptiles.*

1. Of their motions - - 287
2. Of ſerpents - - ib.
The aſtoniſhing number of their bones 288
Different ſorts of ſerpents 289
3. Of their brain, ſtomach, generation ib.
4. Of the venom of ſerpents and vipers 290
The ſwiftneſs of the poiſon of a rattle-ſnake 291
Singular properties of the rattle-ſnake ib.
Particular account of a perſon bit by a rattle-ſnake - - - 293
Of ſome particular ſort of reptiles 294
Of the water-ſnake - - ib.
Of the ſerpent of the waters - 295
Of the crocodile, the king of reptiles ib.
The American crocodile, or alligator ib.
Of the cameleon - - 296
Four ſpecies of cameleons: the Arabian, the Egyptian, the Mexican, the European 297
The uncommon ſtructure and motion of their eyes - - - ib.
Peculiarities of the cameleons in Smyrna 298
Of the ſalamander - - ib.
Of the Oocarel of Lower Egypt reſembling a crocodile - - ib.

Of

		Page
	Of the lizards and ſcorpions of Italy	299
6.	Water lizards often change their ſkins	ib.
	A particular ſpecies of water lizards termed an aquatic ſalamander	300
7.	Reproduction of parts cut off	ib.
	The remarkable productions of the parts of a ſalamander	301
	Of thoſe of the tad-pole	ib.
	Of thoſe of the earth-worm	ib.
	Of thoſe of the aquatic boat-worm	302
	Of thoſe of the ſnail	ib.
8.	Of tape-worms	303
9.	Of worms that feed on ſtones	304
	Of the common leech	ib.
	Of frogs changing their ſkins	305
	The remarkable longevity of a toad	306

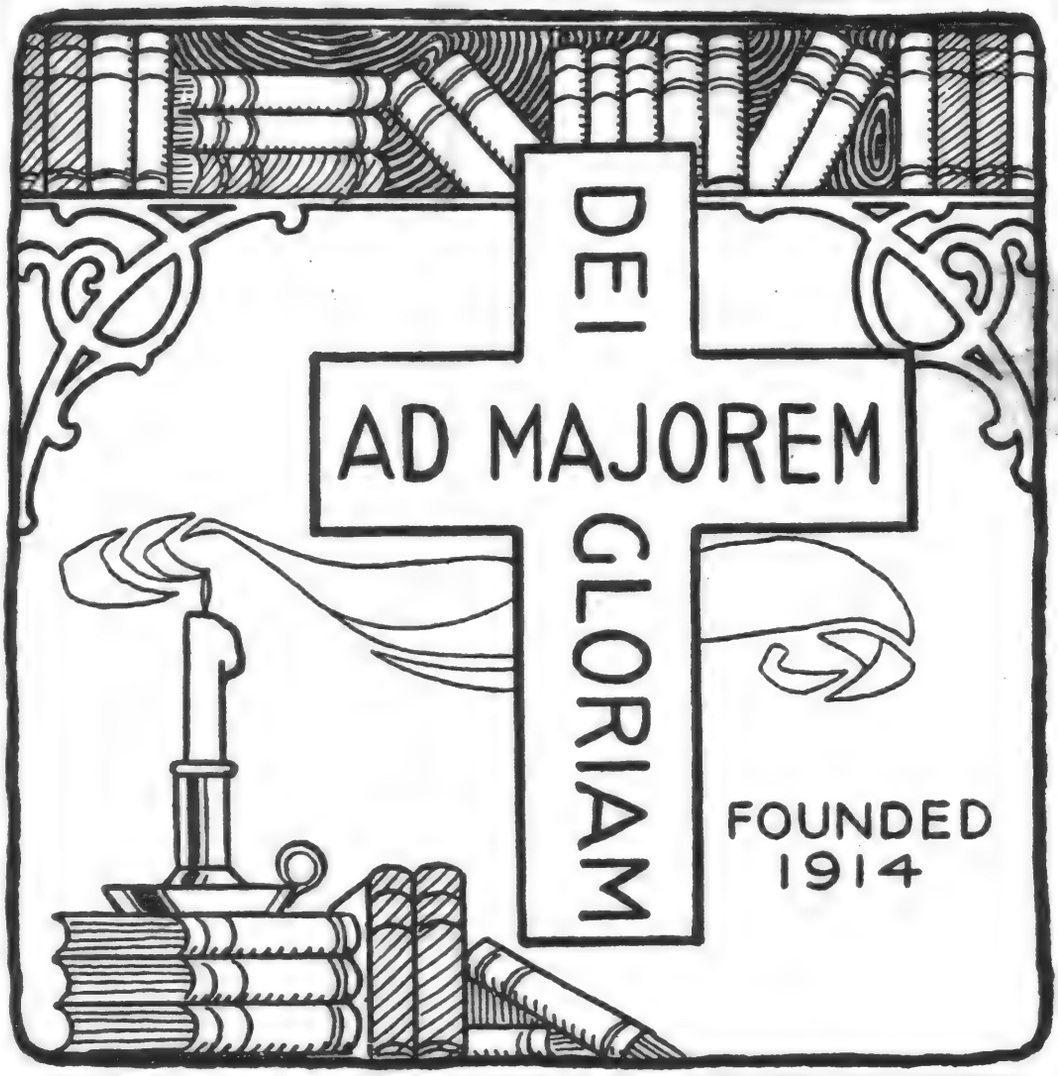
END OF THE FIRST VOLUME.

Special
collec.
BW264
.W4S8
1810
v. 1

VOLUME 2

BW 264
W458
1810 v.2

School of Theology



THEOLOGICAL LIBRARY
Thursfield Smith Collection, No._____

Wes 297

A SURVEY OF THE WISDOM OF GOD IN *THE CREATION:* OR, A COMPENDIUM OF NATURAL PHILOSOPHY.

IN FOUR VOLUMES.

By JOHN WESLEY, M. A.

THE SIXTH EDITION.

VOL. II.

These are thy glorious Works, Parent of Good,
Almighty! Thine this universal Frame,
Thus wond'rous fair! Thyself how wond'rous then!

MILTON.

DUBLIN:
PRINTED BY R NAPPER, 29, CAPEL-STREET;
And sold at the Methodist Preaching Houses in Town & Country.

1810.

A

COMPENDIUM

OF

NATURAL PHILOSOPHY.

CHAP. V.

Of INSECTS.

1. *Of their Shape and Make.*
2. *Of their Eyes.*
3. *Their Heart, Reſpiration.*
4. *Their Generation, particularly the Silk-Worm and Silk-Spider.*
5. *Of the common Spider.*
6. *Of the Tarantula.*
7. *Of the Coya.*
8. *Of Miſcroſcopic Animals.*
9. *Of the Flea.*
10. *Of the Louſe.*
11. *Of the Death-watch.*
12. *Of the Eggs of Flies.*
13. *Of Gnats.*
14. *Of the Cicadula.*
15. *Of the Drone-Fly.*
16. *Of the Fire-Fly.*
17. *Of the Ephemeron.*
18. *Of Butterflies.*
19. *Of Caterpillars.*

20. *Of the Transformation of Inſects.*
21. *Of Ants.*
22. *Of the Ant-Eater.*
23. *Of Bees.*
24. *Of the Polypus.*
25. *Of the Transformation of Animals.*

THERE remains only the loweſt order of animals, uſually termed inſects, becauſe they have an inciſion, as it were, which in a manner cuts them in two parts. Of theſe I would ſpeak the more largely, becauſe generally they are little known.

Rather they are deſpiſed, and purpoſely paſſed over, as unworthy of our conſideration. And yet it is certain, the wiſdom of the great Creator does moſt conſpicuouſly ſhine in them.

1. As to the ſhape of their bodies, though it be ſomewhat different from that of birds, being for the moſt part not ſo ſharp before, to cut and make way through the air, yet it is better adapted to their manner of life. For conſidering they have little need of long flights, and that the ſtrength and activity of their wings, far ſurpaſs the reſiſtance they meet with from the air, there was no occaſion for their bodies to be ſo ſharpened. But the nature of their food, the manner of gathering it, and the great neceſſity they had of accurate viſion, and large eyes in order thereto, required the largeneſs of the head, and its amplitude before the reſt of the body is all well made, and nicely poiſed for their flight and other occaſions.

The make of their bodies is no leſs admirable: not built throughout with bones, covered over with fleſh, and then with ſkin, as in moſt other animals: but clothed with a curious mail of a middle nature, ſerving both as a ſkin and bone too; as it were on purpoſe to ſhew, that the great Contriver of nature is not bound up to one way only.

How admirably are the legs and wings fitted for their intended ſervice? Not to overload the body nor to retard it, but give it the moſt proper and convenient motion. What for example, can be better contrived

trived for this ſervice than the wings? Diſtended and ſtrengthened by the fineſt bones; and theſe covered with the fineſt and lighteſt membranes; and many of them provided with the fineſt articulations, and foldings, in order to be laid up in their caſes, when they do not uſe them; and yet always ready, to be extended for flight.

2. The ſtructure of the eye is in all creatures an admirable piece of mechaniſm. But this is peculiarly obſervable in that of an inſect. Its hardneſs is an excellent guard againſt external injuries; and its outer coat is all over beſet with curious, tranſparent inlets, enabling it to ſee every way, without any loſs of time, or trouble to move the eyes.

And their feelers, beſides their uſe in cleaning the eyes, are a good guard to them in their walk or flight, enabling them by the ſenſe of feeling to diſcover annoyances, which, by their nearneſs, might eſcape the ſight.

The eye of a fly is in truth an aſſemblage of multitudes, often many thouſands of ſmall eyes. Nature has given each fly two large reticular eyes (that are covered with a kind of net-work.) And as each contains ſuch a multitude of ſmaller eyes, one would imagine this might ſuffice. Yet ſome flies have four reticular eyes; the two ſmaller are placed as uſual, the two larger are behind the other, on the upper part of the head.

In different ſpecies the reticular eyes are of different colours. Some are brown, ſome yellow, green, red, and this in all the different ſhades of thoſe colours. And ſome have the gloſs of metals highly poliſhed.

But beſide theſe, many ſpecies of flies have a ſort of eyes, which are not reticular, but of a perfectly ſmooth and even ſurface, and far ſmaller than the reticular. Three of theſe are on the back of the head of vaſt numbers, which are triangularly placed. Some have more, and ſome have leſs than three. Gnats have none of them. Their heads are in a manner covered with their reticular eyes, ſo as to leave no room or occaſion for ſmooth ones.

Nor are theſe ſmooth eyes peculiar to flies. Other inſects

inſects alſo have them: the graſshopper in particular has two, which are placed near the noſe.

3. The ſpecies of inſects are almoſt innumerable. All of theſe, ſome ſuppoſe to have no heart, as they have no ſenſible heat, none that can be perceived either by the touch, or by any other experiment. But this is a miſtake. Many indeed have not ſuch a heart as other animals have: but all have ſomething analogous to it, ſomething that anſwers the ſame purpoſe.

Some likewiſe have thought, that inſects have no reſpiration. But later experiments ſhew, that there is no ſpecies of them which has not lungs, and theſe larger in proportion than other animals. In moſt of them they lie on, or near the ſurface of the body. And hence it is, that if flies are beſmeared with oil, or any other unctuous matter, they die in a ſhort time, their reſpiration being ſtopt, ſo that they are properly ſuffocated.

4. Some alſo have imagined, that inſects were generated out of mere putrefaction, becauſe they obſerved worms come out of putrefied fleſh, which afterwards turned to flies. But it is certain, if putrefying fleſh be ſhut up cloſe, no worms are ever generated from it. Hence we learn, that flies lay their eggs in fleſh, which hatch when it putrefies: ſo that the animal juſt comes to life when its food is ready for it. All inſects lay their eggs, where there is heat enough to hatch them, and proper food as ſoon as they are hatched. Thoſe whoſe food is in the water, lay their eggs in the water: thoſe to whom fleſh is a proper food, in fleſh: thoſe to whom the fruits or leaves of vegetables are food, are depoſited on the proper fruits or leaves. And conſtantly the ſame kind is found on the ſame fruit or plant. Thoſe that require more warmth, are lodged by the parent, in or near the body of ſome animal. And as for thoſe to whom none of theſe methods are proper, the parents make them neſts by perforations in the earth, in wood, in combs: carrying in and ſealing up proviſions, that ſerve both to produce the young, and to feed them when produced.

The

The eggs of all inſects become worms, commonly called nymphæ. They are next changed into aureliæ, ſo called, encloſed in a caſe; and theſe dying, a fly or butterfly ſucceeds.

Some aurelia ſhine like poliſhed gold. From the beautiful and reſplendent colours, ſome authors have called it a chryſalis, implying a creature made of gold. This brilliant hue, which does not fall ſhort of the beſt gilding, is formed in the ſame manner in which we ſee leather obtain a gold colour; though none of that metal ever enters into the tincture. It is only formed by a brown varniſh laid upon a white ground; and the light thus gleaming through the tranſparency of the brown gives a charming golden yellow. Theſe two colours are found one over the other in the aurelia and the whole appears gilded, without any real gilding.

To trace theſe wonderful changes a little, in one kind of inſects. A ſilk-worm, from a ſmall egg, becomes a worm of the caterpillar-kind, and feeds on mulberry-leaves, till it comes to maturity. Then it winds itſelf up into a ſilken caſe, about the ſize and ſhape of a pigeon's egg, and is metamorphoſed into an aurelia, in which ſtate it has no motion or ſign of life: till at length it awakes, breaks through its ſilken ſepulchre, and appears a butterfly.

As ſoon as the ſilk-worm has ſtrength, he makes his web, a ſlight tiſſue, which is the ground of this admirable work. This is his firſt day's employ. On the ſecond, he covers himſelf almoſt over with ſilk. The third, he is quite hid. The following days he employs in thickening his ball, always working from one ſingle end ſo fine a thread, that thoſe who have examined it, affirm it would reach ſix miles.

The ſilk-ſpider makes a thread, every whit as ſtrong, gloſſy, and beautiful as the ſilk-worm. It ſpins from ſeven nipples. Theſe, as ſo many wire-drawing irons, draw out a viſcous liquor, which gradually dries in the air, and becomes ſilk.*

Each

* All boneleſs inſects are hermaphrodites, as are ſnails, leeches, and many ſorts of worms. But ſuch worms as become flies are not, being indeed of no ſex.

Each of theſe nipples contains many ſmaller nipples, inviſible to the naked eye; through the ſeveral perforations, whereof, numberleſs finer threads are drawn. Before the ſpiders begin to ſpin, they apply more or fewer of the large nipples to the body whence the web is begun. And as they apply them more or leſs ſtrongly, more or fewer of the ſmaller nipples come to touch: and accordingly the whole thread will be compounded of more or fewer ſingle threads. One compound thread frequently conſiſts of fifteen or ſixteen ſingle ones.

Their threads are of two kinds: one ſerves only for the web with which they catch flies. The other is much thicker and ſtronger, in which they wrap up their eggs, in order to ſhelter them from the cold, as well as from devouring inſects. Theſe threads they wind looſely round, reſembling the balls of ſilk-worms that have been looſened for the diſtaff.

The balls are grey at firſt, but turn blackiſh when long expoſed to the air. From theſe balls a ſilk is made, nothing inferior to the common ſilk. It takes all kinds of dyes, and may be made into all kinds of ſtuffs. Only there is a difficulty in keeping the ſpiders: for they are ſo extremely quarrelſome, that if a hundred of them be put together, in a few hours ſcarce twenty will be alive.

5. Amazing wiſdom is diſplayed in the make of the common ſpider. She has ſix teats, each furniſhed with innumerable holes. The tip of each teat is divided into numberleſs little prominences, which ſerve to keep the threads apart at their firſt exit, till they are hardened by the air. In every teat, threads may come out at above a thouſand holes. But they are formed at a conſiderable diſtance, each of them having a little ſheath, in which it is brought to the hole. In the belly are two little ſoft bodies, which are the firſt ſource of the ſilk. In ſhape and tranſparency they reſemble glaſs beads, and the tip of each goes winding toward the teat. From the root of each bead proceeds another branch much thicker, which alſo winds towards the ſame part. In theſe beads and their branches is contained the matter of which the

ſilk is formed, the body of the bead being a kind of reſervoir; the two branching canals proceeding from it.

It was before obſerved, that the tip of each teat may give paſſage to above a thouſand threads. And yet the ſize of the teat in the largeſt ſpider does not exceed a ſmall pin's head. But the ſmalleſt ſpiders no ſooner quit their eggs than they begin to ſpin. Indeed their threads can ſcarce be perceived, but the web formed thereof is as thick and cloſe as any. And no wonder, as four or five hundred little ſpiders often concur in the ſame work. How minute are their teats! When perhaps the whole ſpider is leſs than the teat of its parent. Each parent lays four or five hundred eggs, all wrapt up in a bag. And as ſoon as the young ones have broken through the bag, they begin to ſpin.

And even this is not the utmoſt which nature does. There are ſome kinds of ſpiders ſo ſmall, as not to be diſcerned without a microſcope. And yet there are webs found under them! What muſt be the fineneſs of theſe threads? To one of theſe the fineſt hair is as a cart-rope.

There are ſeveral ſpecies of ſpiders that fly, and that to a ſupriſing height. "The laſt October," ſays an eminent writer, "I took notice that the air was very full of webs. I forthwith mounted to the top of the higheſt ſteeple on the Minſter [in York] and could thence diſcern them yet exceeding high above me. Some of the ſpiders that fell upon the pinnacles I took, and found them to be of a kind, which ſeldom or never enter houſes and cannot be ſuppoſed to have taken their flight from the ſteeple.

There are divers animals as well as ſpiders, that have ſome way of conveyance, utterly unknown to us. Thus the animals on the ſtanding waters, ſo numerous as often to diſcolour them, and tinge them red, yellow, or green. That theſe have ſome way of conveyance is certain, becauſe not only moſt ſtagnating waters are ſtocked with them, yea, not only new pits and ponds, but even holes, and gutters on the top of houſes, churches, and ſteeples. That they have not legs for travelling ſo far, is manifeſt; it is there-

fore probable, either that they dart out webs, and can make themſelves buoyant, and lighter than the air: or that their bodies are naturally lighter than air, and ſo they can ſwim from place to place. It is highly probable, the eggs of ſuch as are oviparous may be light enough to float therein.

To trace this matter farther: every one muſt have obſerved threads floating in the air: but few conſider what end they ſerve. They are the works of ſpiders. Their uſual method is, to let down a thread, and then draw it after them. But in the midſt of this work they ſometimes deſiſt; and turning their tail according to the wind, emit a thread with as great violence, as a jet of water diſcharged from a cock. Thus they continue darting it out, which the wind carries forward, till it is many yards long. Soon after, the ſpider throws herſelf off from her web, and truſting herſelf to the air, with this long tail, will aſcend ſwift, and to a great height with it. Theſe lines, which the ſpiders attach to them (though unobſerved) make theſe air-threads, that waft them along the air, and enable them to prey on many inſects, which they could not reach by any other means.

All ſpiders that ſpin, young as well as old, caſt out their threads, and ſail thereby in the air. And the threads themſelves ſhew the uſe thereof, being uſually hung with the fragments of devoured animals.

When the threads are newly ſpun, they are always ſingle, and are generally ſeen aſcending higher and higher. But when they are ſeen coming down, they are ſometimes compoſed of three or four, and either without any ſpider or with ſeveral. It is plain this happens from the threads meeting and entangling in the air, which of courſe brings them down.

It is common to ſee a ſpider mount to the topmoſt branch of a buſh, and from thence dart out ſeveral threads one after another, trying, as it were, how ſhe likes them. When ſhe has darted one ſeveral yards, ſhe will of a ſudden draw it up again, and wind it into a link with her fore-feet, but more frequently break it off, and let it go. A ſpider will ſometimes dart out and break off many threads, before it ſpins one that it

will

will truſt to. But at length ſhe ſpins one to her liking, and commits herſelf to the air upon it.

The buſineſs of feeding is not all the uſe of theſe threads; but they evidently ſport and entertain themſelves by means of them, floating to and fro in the air, and changing their height at pleaſure.

Theſe air-threads are not only found in autumn, but even in the depth of winter. The ſerene days at Chriſtmas bring out many: but they are only ſhort and ſlender, being the work of young ſpiders, hatched in autumn, and are thrown out as it ſeems only in ſport. The thicker ones of autumn are the only ones intended to ſupport the old ſpiders, when there is plenty of ſmall flies in the air, which make it worth their while to ſail among them.

6. A tarantula is a kind of ſpider, chiefly found near the city of Tarentum, in Apulia. It is about the ſize of an acorn, and has eight eyes and eight feet. Its ſkin is hairy; from its mouth riſe two trunks, a little crooked and exceeding ſharp. Through theſe it conveys its poiſon: they ſeem likewiſe to be a kind of moving noſtrils, being in continual motion, eſpecially when it is ſeeking its food. It is found in other parts of Italy, but is dangerous only in Apulia. And there it does little hurt in the mountains (which are cooler) but chiefly on the plains. Indeed it is not venomous, but in the heat of ſummer, particularly in the dog-days. It is then ſo enraged as to fly upon any that come within its reach.

The bite cauſes a pain, like that by the ſtinging of a bee. In a few hours the patient feels a numbneſs, and the part is marked with a ſmall circle, which ſoon riſes into a painful tumour. A little after he falls into a deep ſadneſs, breathes with much difficulty, his pulſe grows feeble, and his ſenſes dull. At length he loſes all ſenſe and motion, and dies, unleſs ſpeedily relieved. A naverſion to blue and black, and an affection for white, red, and green, are other unaccountable ſymptoms of this diſorder.

There is no remedy but one. While he lies ſenſeleſs and motionleſs, a muſician plays ſeveral tunes. When he hits on the right, the patient immediately begins to

make

make a faint motion. His fingers firſt move in cadence, then his feet: then his legs, and by degrees his whole body. At length he riſes on his feet, and begins to dance, which ſome will do for ſix hours without intermiſſion. After this he is put to bed, and when his ſtrength is recruited, is called up by the ſame tune to a ſecond dance.

This is continued for ſix or ſeven days at leaſt, till he is ſo weak, that he can dance no longer. This is the ſign of his being cured; for if the poiſon acted ſtill, he would dance till he dropt down dead. When he is thoroughly tired he awakes as out of ſleep, without remembering any thing that is paſt. And ſometimes he is totally cured; but if not, he finds a melancholy gloom, ſhuns men, ſeeks water, and if not carefully watched leaps into a river. In ſome the diſorder returns that time twelvemonth, perhaps for twenty or thirty years. And each time it is removed as at firſt. Can even Dr. Mead account for this?

Equally unaccountable are the two relations publiſhed ſome years ſince, by a phyſician of undoubted credit. The firſt is, a gentleman was ſeized with a violent fever, attended with a delirium. On the third day he begged to hear a little concert in his chamber. It was with great difficulty the phyſician conſented. From the firſt tune, his face aſſumed a ſerene air, his eyes were no longer wild, and the convulſions ceaſed. He was free from the fever during the concert; but when that was ended, it returned. The remedy was repeated, and both the delirium and fever always ceaſed during the concerts. In ten days, muſic wrought an entire cure, and he relapſed no more.

The other caſe is that of a dancing-maſter, who through fatigue, fell into a violent fever. On the fourth or fifth day he was ſeized with a lethargy, which after ſome time changed into a furious delirium. He threatened all that were preſent, and obſtinately refuſed all the medicines that were offered him. One of them ſaying, that perhaps muſic might a little compoſe his imagination, a friend of his took up his violin, and began to play on it. The patient ſtarted up in his bed, like one agreeably ſurpriſed, and ſhewed by his head (his arms being held) the pleaſure he felt. Thoſe who held

held his arms, finding the effects of the violin, looſened their hold, and let him move them, according to the tunes. In about a quarter of an hour, he fell into a deep ſleep. When he awoke he was out of all danger.

We have many other odd accounts of the power of muſic; and it muſt not be denied, but that on ſome particular occaſions, muſical ſounds may have a very powerful effect. I have ſeen all the horſes, and cows in a field, where there were above a hundred, gather round a perſon that was blowing a French horn, and ſeeming to teſtify an aukward kind of ſatisfaction. Dogs are well known to be very ſenſible of different tones in muſic; and I have ſometimes heard them ſuſtain a very ridiculous part in a concert.

The great old lion which was ſome years ſince kept at the infirmary in Edinburgh, while he was roaring with the utmoſt fierceneſs, no ſooner heard a bag-pipe, than all his fierceneſs ceaſed, He laid his ear cloſe to the front of the den, nibbled his noſe and his teeth againſt the end of his pipe, and then rolled upon his back for very glee. I have ſeen a German flute have the ſame effect on an old lion, and a young tyger in the tower of London.

7. There is found in America a kind of ſpider more miſchievous than even the tarantula, chiefly in the vallies of Neyba, and others within the juriſdiction of Popayon. It is called a coya. It is much leſs than a bug, and is of a fiery red colour. It is found in the corners of walls and among the herbage. On ſqueezing it, if any moiſture from it falls on the ſkin of either man or beaſt, it immediately penetrates the fleſh, and cauſes large tumours, which are ſoon followed by death.

The only remedy is, on the firſt appearance of a ſwelling, to ſinge the perſon all over the body with a flame of ſtraw, or of the long graſs growing on thoſe plains. This the Indians perform with great dexterity, ſome holding him by the feet, others by the hands.

Travellers here are warned by their Indian guides, if they feel any thing crawl on their neck or face, not even to lift their hand, the coya being of ſo delicate a texture,

texture, that it would immediately burſt. But let them tell the Indian what they feel, and he comes and blows it away.

The beaſts which feed there, are taught by inſtinct, before they touch the herbage with their lips, to blow on it with all their force, in order to clear it of theſe pernicious vermin. And when their ſmell informs them, that a coya's neſt is near, they immediately leap and run to ſome other part. Yet ſometimes a mule, after all his care, has taken in a coya with his paſture. In this caſe after ſwelling to a frightful degree, it expires upon the ſpot. Thus does even the irrational creation "groan and travel in pain together," until it ſhall be "delivered into the glorious liberty of the children of God!"

8. Mention was made of the extreme ſmallneſs of ſome ſpiders. But how much ſmaller are thoſe animalcula, diſcerned by the microſcope? Theſe are in almoſt all water. Even in that wherein the beſt glaſſes can diſcover no particles of animated matter, after a few grains of pepper, or a ſmall fragment of a plant of almoſt any kind has been ſometime in it, animals full of life are produced and ſo numerous as to equal the fluid itſelf in quantity.

A ſmall quantity of water taken from any ditch in ſummer, is found to abound with juſt ſuch creatures, only larger. Nay any water, ſet in open veſſels in the ſummer months, will after a few days, yield multitudes of them.

Theſe we know by their future changes are the fly-worms of gnats, and ſeveral other ſorts of flies. And we eaſily judge, they owe their origin to the eggs of the parent-fly there depoſited. No doubt then but the air abounds with other animalcula, as minute as the worms in theſe fluids. And theſe are the flying worms of theſe animalcula which after a proper time ſpent in that ſtate, will become flies like thoſe to which they owe their origin.

The waters in which different liquors are infuſed afford a proper matter for the worms of different ſpecies of flies. And ſome of theſe doubtleſs are viviparous, others oviparous. This may occaſion the diffe-

rent

rent time taken up for producing inſects in different fluids. Thoſe proper for the worms of a viviparous fly, will be ſooneſt full of them: whereas a longer time is required to hatch the eggs of the oviparous.

Now every animalcule being an organized body, how delicate muſt the parts be that are neceſſary to make it ſuch, and to preſerve its vital actions? It is hard to conceive, how in ſo narrow a compaſs, there is a heart, to be the fountain of life, muſcles neceſſary for its motion, glands to ſecrete its fluids, ſtomach and bowels to digeſt its food, and other innumerable parts, without which an animal cannot ſubſiſt. And every one of theſe muſt have fibres, membranes, coats, veins, arteries, nerves, and an infinite number of tubes, whoſe ſmallneſs exceeds all efforts of imagination. And yet there are parts that muſt be infinitely ſmaller than theſe, namely the fluids that move through them, the blood, lymph and animal ſpirits, whoſe ſubtility even in large animals, is incredible.

As to ſome of the animalcules obſerved by Lewenhoeck, he computed, that three or four hundred of them placed cloſe together in a line, would only equal the diameter of a grain of ſand. Twenty-ſeven millions then of theſe animals equal in bulk a grain of ſand!

But Hartſoeker carries the matter ſtill farther. If, ſays he, according to our preſent ſyſtem of generation, all animals were formed from the beginning of the world, and encloſed one within another, and all of them in the firſt animal of each ſpecies: how minute muſt the animalcula produced now, have been at the beginning?

9. Even the meaneſt and moſt contemptible of inſects, ſhews the wiſdom of its Creator. Fleas, for inſtance, depoſit their eggs only on ſuch animals as afford them a proper food. Theſe hatch into worms of a ſhining pearl-colour, which feed on the ſcruff of the cuticle. In a fortnight they are very active, and if diſturbed, ſuddenly roll themſelves into a ball. Soon after they begin to creep, with a very ſwift motion. When arrived at their full ſize, they ſpin a thread out of their mouth, wherewith they form themſelves a caſe. After a fortnight's reſt here, each of them

burſts

burſts a perfect flea, leaving its exuviæ behind. It is milk-white till the ſecond day before its eruption: then it changes colour and gets ſtrength, ſo that upon its firſt delivery, it ſprings nimbly away.

Minute animals are found proportionably much ſtronger and more active than large ones. The ſpring of a flea in its leap vaſtly exceeds any thing greater animals are capable of. Mr. De Liſle has computed the velocity of a little creature, which ran three inches in half a ſecond. Now ſuppoſing its feet to be the fifteenth part of a line, it muſt then, in order to travel over ſuch a ſpace in ſuch a time, make five hundred ſteps in the ſpace of three inches: that is, muſt ſhift its feet five hundred times in a ſecond, or in the ordinary pulſation of an artery. What is the motion of any large animal, in compariſon of this? Or what is the ſwiftneſs of a greyhound or a race-horſe, to that of ſuch an animalcule?

The body of a flea appears, by a microſcope, to be all over curiouſly adorned with a ſuit of poliſhed ſable armour, neatly jointed, and beſet with multitudes of ſharp pins. It has ſix legs, the joints of which are ſo adapted, that it can fold them up one within another; and when it leaps, they all ſpring out at once, whereby its whole ſtrength is exerted, and the body raiſed above two hundred times its own diameter.

10. A louſe alſo affords to our obſervation a very delicate ſtructure of parts. It is divided into the head, the breaſt, and the tail. In the head appear two fine black eyes, with a horn that has five joints, and is ſurrounded with hairs, ſtanding before each eye. From the noſe projects in a ſheath the piercer or ſucker, which it thruſts into the ſkin. This is judged to be ſeven hundred times finer than a hair. It has no other mouth than this.

The ſkin of the breaſt is tranſparent, and from the under part of it proceed ſix legs, each having five joints; each leg is terminated by two claws, which it uſes as we would a thumb and middle finger.

If one of them, when hungry, be placed on the back of the hand, it will thruſt its ſucker into the ſkin, and the blood it ſucks may be ſeen paſſing in a fine ſtream

to

to the fore-part of the head. Falling into a roundiſh cavity there, it paſſes on to another receptacle in the middle of the head. Thence it runs to the breaſt, and then to a gut which reaches to the hinder part of the body, where in a curve it turns again a little upward. It then ſtands ſtill, and ſeems to undergo a ſeparation: ſome of it becoming clear and watry, while other black particles paſs down to the anus.

Lice are not hermaphrodites; and the males have ſtings, which the females have not. A female lays in twelve days a hundred eggs, which hatch in ſix days. Suppoſe theſe produce fifty males, and as many females: theſe females coming to their full growth in eighteen days may each in twelve days lay a hundred eggs more. And theſe in ſix days more may produce a young brood of five thouſand. So ſwifty do theſe creatures multiply!

Moſt animals are ſubject to lice, but each of a different kind, and none of them like the human. Nay, even inſects are not free. Beetles, ear-wigs and ſnails, are particularly ſubject to them. Numberleſs little red lice are often ſeen about the legs of ſpiders. A ſort of whitiſh lice are common on bees. They are alſo found on ants.

Fiſhes, one would think, living in the water, and perpetually moving to and fro, ſhould be free from lice. But they have their ſorts too, which neſt under their ſcales, the ſalmon in particular. Beſide which, there are frequently found great numbers of long worms, in the ſtomach and other parts of fiſh. And theſe work themſelves ſo deeply into their fleſh, that they cannot eaſily be got out.

Many inſects are bred in the noſtrils of ſheep. One may take out twenty or thirty rough maggots at a time. A rough, whitiſh maggot is found alſo within the inteſtinum rectum of horſes. Others are generated in the backs of cows, which at firſt are only a ſmall knot, being an egg laid there by ſome inſect. Afterward it grows bigger, and contains a maggot, lying in a purulent matter.

In Perſia, ſlender worms, ſix or ſeven yards long, are bred in the legs and other parts of men's bodies. Yea, there have been divers inſtances of worms taken

out of the tongue, gums, noſe, and other parts, by a perſon of Leiceſter, before many witneſſes.

11. A very extraordinary kind of inſect is that which is called a death-watch, becauſe it makes a noiſe like the beating of a watch. They are of two kinds. One is a ſmall beetle, ſomewhat more than a quarter of an inch long, of a dark brown, and ſpotted, having a large cap on the head, and two feelers ſpringing from beneath the eyes. Dr. Derham obſerved it to draw back its mouth, and beat with its forehead. He kept two, a male and a female, in a box, for ſome months, and could bring one of them to beat when he pleaſed, by imitating its beating. And he ſoon found this ticking to be the way, whereby they wooed one another.

The other kind is a greyiſh inſect like a louſe, which beats ſome hours together without intermiſſion, and that ſlowly; whereas the former beats only ſeven or eight ſtrokes at a time, and much quicker. It is very common in ſummer in all parts of our houſes, is nimble in running to ſhelter, and ſhy of beating, if diſturbed; but is free to beat, and to anſwer your beating, if you do not ſhake the place where it lies. This commonly, if not always, beats in or near paper. It is at firſt a ſmall, white egg, like a nit. It hatches in March, and creeps about with its ſhell on. It is then ſmaller than the egg itſelf, but ſoon grows to the perfect ſize.

That death-watches do woo one another, but not always, we may learn from the account of an accurate obſerver. "As I was in my ſtudy, I happened to hear what is called a death-watch. Inclining my head toward a chair, I found it was beating there. The manner of its beating was this. It lifted up itſelf on its hinder legs, and extending its neck, ſtruck its face upon the ſedge, which was bared upon its outward coat, about the length of half an inch. The impreſſion of its ſtrokes was viſible: the outward coat of the ſedge being depreſſed, where it had juſt been beating, for about the compaſs of a ſilver penny. I am inclined to think it beats for food. There were ſeveral places on the

the ſedge, where it had been at work, and where it had probably been ſojourning for ſome days.

" Poſſibly the inſect may ſometimes woo its mate by beating thus: but it was not the caſe now. It had not any other of its kind near it. It ſeemed therefore to be preparing its food. It was about a quarter of an inch long, of a dark, dirty colour, having a broad helmet over its head, which he can draw up under it, ſo that it is a notable defence againſt the falls, to which he is continually expoſed, creeping over rotten and decayed places.

" The ſecond day after I took it, I opened the box, and ſet it in the ſun. It was ſoon very briſk, and crept nimbly to and fro, till ſuddenly it ſtruck out its wings, and was going to take its leave; but on my ſhading it over, it drew in its wings, and was quiet."

This ſeems to be the ſmalleſt of the beetle-kind. A gentleman deſcribes one of a very different ſort, in the Philoſophical Tranſactions. " On the removal of a large leaden ciſtern, I obſerved at the bottom of it black beetles. One of the largeſt I threw into a cup of ſpirits, (it being the way of killing and preparing inſects for my purpoſe.) In a few minutes it appeared to be quite dead. I then ſhut it up in a box about an inch and a half diameter, and throwing it into a drawer, thought no more of it for two months, when opening the box, I found it alive and vigorous, though it had no food all the time, nor any more air than it could find in ſo ſmall a box, whoſe cover ſhut very cloſe. A few days before, a friend had ſent me three or four cock-roaches.

Theſe I had put under a large glaſs; I put my beetle among them, and fed them with green ginger, which they ate greedily; but he would never taſte it, for the five weeks they lived there. The cock-roaches would avoid the beetle, and ſeemed frightened at his approach: but he uſually ſtalked along, not at all regarding whether they came in his way or not. During the two years and a half that I have kept him, he has neither eat nor drank.

" How then has he been kept alive? Is it by the air? There are particles in this, which ſupply a growth to ſome ſpecies of plants, as ſempervive, orpine and houſeleek:

leek: may not the ſame or the like particles ſupply nouriſhment to ſome ſpecies of animals? In the amazing plan of nature, the animal, vegetable and mineral kingdoms, are not ſeparated from each other by wide diſtances, but near their boundaries, differ from each other, by ſuch minute and inſenſible degrees, that we cannot find out certainly, where the one begins, or the other ends. As the air therefore nouriſhes ſome plants, ſo it may nouriſh ſome animals: otherwiſe a link would ſeem to be wanting, in the mighty chain of beings. It is certain camelions and ſnakes can live many months without any viſible ſubſiſtence: and probably not merely by their ſlow digeſtion, but rather by means of particles contained in the air, as this beetle did; yet doubtleſs in its natural ſtate, it uſed more ſubſtantial food. So the plants above-named thrive beſt with a little earth, although they flouriſh a long time, and ſend forth branches and flowers, when they are ſuſpended in the air.

"Even in the exhauſted receiver, after it had been there half an hour, it ſeemed perfectly unconcerned, walking about as briſkly as ever. But on the admiſſion of the air, it ſeemed to be in a ſurpriſe for a minute.

"After I had kept him half a year longer, he got away, through the careleſſneſs of a ſervant who took down the glaſs."

12. A female fly, within four and twenty hours after her congreſs with the male, begins to depoſit her eggs on ſome ſubſtance proper to give nouriſhment to the worm that is to be produced. Theſe eggs in general are white and oblong. But there are ſome of them which are ſingular. To deſcribe one ſpecies of them may ſuffice, the eggs laid on hog's dung.

They are white and oblong, but of a peculiar make. At one end of each of theſe eggs, between that end and the middle, are two little wings, ſtanding out on either ſide. As ſoon as the fly has laid her eggs, ſhe thruſts them into the dung. This keeps the coat of the egg ſoft; otherwiſe the embryo could never get out. But if the whole egg were thruſt in, the creature would be ſuffocated as ſoon as it is hatched. Therefore

fore part only is to be immerſed, and part to be left out. And this is admirably provided for by theſe wings. For when the female thruſts in the egg, it eaſily enters at the ſmaller end, which is the part firſt protruded from her body: but it ſtops at the wings, and ſo the upper part remains open to the air.

Some ſpecies of flies faſten their eggs to the ſides of veſſels of water. All theſe eggs have a thin flake running down the two ſides diametrically oppoſite; ſo that they look as if they were encloſed in a frame. The uſe of this frame is, to hold the body of the egg more firmly to the ſide of the veſſel. Thoſe eggs which have it not, are depoſited by the female fly with a viſcous matter about them.

Some flies lay their eggs in the bodies of caterpillars. Theſe are at great pains to carry thoſe crterpillars to the places where it is proper their eggs ſhould be hatched. There is one ſpecies whoſe worm can never ſucceed, unleſs it be both bred in the caterpillar, and that caterpillar buried under ground. To this purpoſe the parent, when ready to lay her eggs, forms a hole in the ground, and covers it with a little clod. Then ſhe goes in ſearch of a proper caterpillar, perhaps one much larger than herſelf, which nevertheleſs ſhe drags to her hole. This ſhe uncovers, and goes in to ſee if all is right. Then ſhe goes and draws the caterpillar in, depoſits her eggs in his fleſh, and ſtops up the hole with ſeveral pellets of dirt and duſt, careſully rammed in between. When the worms are hatched, they feed on the fleſh of the caterpillar till they are full grown. Then they change into aurelia, and afterward into the form of the parent-fly: in which ſtate they eaſily make their way out of the ground.

Some of theſe lay their eggs in the bodies of ſmaller flies. They often fly with one of them in their legs, the head of it being cloſe to their bellies. They carry theſe to little holes in the ground. In the firſt they lay their eggs. Then they bring others, to be food for their young when hatched. One fly is not enough; therefore their parents carry them more every day, crawling backward into the hole, and dragging in the flies after them. When the worms change into aurelia,

relia, their caſes are made of the exuviæ of the flies they have been feeding on.

The eggs of inſects are uſually the occaſion of what are termed blights. Theſe ſeldom happen but on the blowing of ſharp eaſterly winds. Many inſects attend thoſe winds, and lay their eggs on proper plants. Indeed the large worms or caterpillars which attend ſome blights, ſeem to be only hatched by thoſe winds. But they probably bring thoſe ſwarms of inſects, which occaſion the curling of the leaves of trees.

Every inſect feeds on one plant and no other. On this only it lays its eggs. Hence it is, that one kind of tree only is blighted, and the reſt eſcape. All trees then cannot be blighted at once, unleſs one wind could bring the eggs of all inſects, with as many different degrees of heat and cold, as are required to hatch and preſerve each ſpecies.

And what though we do not always perceive animals in blights? By microſcopes we diſcover animalcula, a million times leſs than thoſe that are perceivable by the naked eye. The gentleſt air may waft theſe from place to place: ſo that it is no wonder if they are brought to us from Great Tartary; even the cold air of which may give them life, and from whence there is not ſo much ſea as to ſuffocate them in its paſſage, by the warmth and ſaltneſs of its vapours.

Trees are preſerved from blights, by ſprinkling them with tobacco-duſt or pepper duſt, which are death to all inſects.

But one kind of blight is cauſed merely by long continued, dry, eaſterly winds. Theſe ſtop the perſpiration in the tender bloſſoms, ſo that in a ſhort time they wither and decay: ſoon after, the tender leaves are affected; their perſpiring matter becoming thick and glutinous, ſo as to be a proper nutriment to the inſects, which are then always found upon them. In this caſe the inſects are not the cauſe, but the effect of the blight.

It is a kind of blight that produces galls, which are the buds of oaks ſwelled out. The cauſe is, into the heart of the tender bud, a fly thruſts one or more eggs. This egg ſoon becomes a worm, and eats itſelf a little cell in the pith of the bud, which would have grown

into

nto a branch. The ſap, which was to nouriſh that branch, being diverted into the remaining parts of the bud, theſe grow large and flouriſhing, and become a covering for the cell of the inſect.

Not only the willow and ſome other trees, but plants alſo, nettles, ground-ivy, and others, have ſuch caſes produced upon their leaves. The parent-inſect, with its ſtiff tail, bores the rib of the leaf when tender, and makes way for her egg into the very pith. Probably ſhe lays it there, with ſome proper juice, to prevent the vegetation of it. From this wound ariſes a ſmall excreſcence, which when the egg is hatched, grows bigger and bigger as the worm increaſes, ſwelling on each ſide the leaf, between the two membranes. This worm turns afterwards to an aurelia, and then to a ſmall green fly.

The Aleppo galls, wherewith we make our ink, are of this number, being only caſes of inſects, which gnawed their way out, through the little holes we ſee in them.

For a ſample of the tender balls, ſee the balls as round, and ſometimes as big as ſmall muſket-bullets, growing under oaken leaves, cloſe to the ribs of a greeniſh yellowiſh colour. Their ſkin is ſmooth, with frequent riſings therein. Inwardly they are very ſoft and ſpungy; and in the very centre is a caſe, with a white worm therein, which afterwards becomes a fly. As to this gall, there is one thing peculiar. The fly lies all winter within this ball, and does not come to maturity till the following ſpring. In the autumn theſe balls fall to the ground with their leaves. Yet the inſect encloſed in them, is fenced againſt the winter froſts, partly by other leaves lying upon them, and partly by the thick ſpungy wall, afforded by the galls themſelves.

13. There are few inſects more prolific than the gnat. All its changes from the egg to the perfect animal are fulfilled in three weeks or a month: and there are uſually ſeven generations of them in a year, in each of which the parent lays two or three hundred eggs. Theſe ſhe ranges in the form of a boat, and each egg is ſhaped like a nine-pin. The thicker ends of theſe

are

are placed downward. They are firmly joined together by their middles, and their narrower parts ſtand upward.

Viewed with a microſcope, the larger end is obſerved to be terminated by a ſhort neck, the end of which is bordered by a kind of ridge. The neck of each is ſunk in the water, on which the boat ſwims: for it is neceſſary they ſhould keep on the ſurface, ſince otherwiſe the eggs could never be hatched.

The ranging theſe in ſo exact order, requires the utmoſt care in the parent. Gnats lay their eggs in the morning hours, and that on ſuch waters, as will give ſupport to their young. Here the parent places herſelf on a ſmall ſtick, a leaf, or any ſuch matter near the water-edge, in ſuch a manner, that the laſt ring but one of her body, touches the ſurface of the water. The laſt ring of all, where there is the paſſage for the eggs, is turned upward, and every egg is thruſt out vertically. When it is almoſt diſengaged, ſhe applies it to the ſides of the cluſter already formed: to which it readily adheres by means of a viſcous matter wherewith they are covered.

The great difficulty is, to place the firſt laid eggs in a proper poſition to receive the reſt, and to ſuſtain themſelves and them, in a proper direction. Theſe ſhe with great precaution places exactly, by means of her hinder legs. And when a ſufficient number of them are arranged, all the reſt is eaſy: inaſmuch as theſe are a firm ſupport to all that follow them.

Theſe are circumſtances ſufficiently extraordinary in this little animal; but it offers ſomething ſtill more curious in the method of its propagation. However ſimilar inſects of the gnat kind are in their appearances, yet they differ widely in the manner in which they are brought forth; for ſome are oviparous, ſome viviparous; ſome are males, ſome are females, ſome are of neither ſex, yet ſtill produce young, without any copulation whatſoever. This is one of the ſtrangeſt diſcoveries in all natural hiſtory! A gnat ſeparated from the reſt of its kind, and encloſed in a glaſs veſſel, with air ſufficient to keep it alive, ſhall produce young, which alſo, when ſeparated from each other, ſhall be the parents of a numerous progeny. Thus down for

five

five or ſix generations do theſe extraordinary animals propagate in the manner of vegetables, the young burſting from the body of their parents, without any previous impregnation. At the ſixth generation, however, their propagation ſtops; the gnat no longer produces its like from itſelf, but requires the acceſs of the male.

14. A cicadula is a ſmall inſect found in May and June, on the ſtalks of leaves or plants, in a kind of froth, commonly called cuckoo-ſpit. This froth is not from the plant, but the mouth of the animal; and if it be gently wiped away, will be preſently ſeen iſſuing out of its mouth, till there is as large a quantity of it as before. They are of the ſhape of a louſe, ſome being whitiſh, ſome yellowiſh, and others green: They often change their ſkins, while they live in this froth, and only creep a little. But when they leave the plant they hop and fly, having wings which cover the whole body.

The cochineal is an inſect of the ſame ſpecies with the gall-inſect. It is found adhering to ſeveral plants; but only one communicates its valuable qualities to it, the opantia or prickle pear. This conſiſts of thick leaves, and its fruit, reſembling a fig, is full of a crimſon juice, to which the inſect owes its colour.

When firſt hatched, it is ſcarce bigger than a mite, and runs about very ſwiftly. But it ſoon loſes its activity, and fixing on the leaſt and moſt juicy part of the leaf, clings there for life, without moving any more, only for its ſubſiſtence, which it ſucks in with its proboſcis.

The male has no appearance of belonging to the ſame ſpecies. They are ſmaller than the female, have wings, and like the butterfly, are continually in motion. They are conſtantly ſeen among the females, walking over them, as it were careleſsly, and impregnating them. But it is the female only which is gathered for uſe, four times in the year; for ſo many are the generations of them.

15. The moſt ſingular part of the life of a drone-

fly, is that it paſſes in the form of a worm. It is then diſtinguiſhed from all other worms by its long tail: at different times this is indeed of different lengths: but it is always longer than the worm itſelf. It is round, ſmooth, and very ſmall at the extremity; ſometimes no thicker than a horſe-hair. To know the uſe of this tail, we muſt firſt know the nature of the worm itſelf. It is an aquatic, and never leaves the water till it changes into its fly-ſtate. They lie in multitudes in the mud at the bottom of veſſels of ſtinking water. Put them into veſſels of clean water, and they will ſoon ſhew the uſe of their tails. Though they live under water, they cannot live without breathing freſh air. This is the end to which their long tails ſerve. For even while they lie buried in the mud, their tails are extended to the top of the water, and being open at the extremity, let air into their bodies. And as ſoon as they are in a veſſel of freſh water, they get to the bottom and thruſt up their tail to the ſurface. They can lengthen them at pleaſure: to be aſſured of this, you need only pour in more water. The worms then lengthen their tails proportionably, in order to breathe from the ſurface: by adding more and more water you will find they can extend their tails to the length of five inches: an extremely remarkable length for a creature little more than half an inch long. Beyond five inches however they cannot go. And if you make the water of a greater depth, they leave the bottom, and either travel up the ſides of the veſſel to a proper height; or elſe ſwim in the water, at the depth of five inches.

16. No ſpecies of flies is more remarkable, than the larger fire-fly of Jamaica. It is above an inch long, and proportionably broad. Moſt of its internal parts are luminous; only the thickneſs of the covers hinders its appearing. But on forcing the rings that cover the body a little aſunder, light iſſues from all the entrails. The head has two ſpots juſt behind the eyes, which emit ſtreams of ſtrong light. But though theſe flow naturally from the inſect, yet it has a power of interrupting them at pleaſure. And then theſe ſpots are as opaque as the ſurface of the body.

A perſon

A perſon may read the ſmalleſt print by the light of one of theſe inſects, if held between the fingers, and moved along the line, with the luminous ſpots over the letters. They are ſeldom ſeen in the day, but wake with the evening, and move and ſhine moſt part of the night. They readily fly toward each other. Hence the negroes have learned, to hold one between their fingers, and wave it up and down, which others ſeeing fly direct toward it, and pitch upon the hand. They are ſo torpid by day, it is hard to make them diſcover ſigns of life; and if they do, they preſently relapſe into the ſame ſtate of inſenſibility. As long as they remain awake, they emit light: but they are vigorous only in the night.

17. One more inſect of the fly-kind, we cannot paſs by unnoticed: the ephemeron, or fly that lives but part of a day. It appears uſually about midſummer. It is produced about ſix in the evening, and dies about eleven. But before it becomes a fly, it exiſts three years as a worm in a clay caſe. It never eats from the time of its change to its death, nor has it any organs for receiving or digeſting food. The buſineſs of its life is ſummed up in a few words. As ſoon as it has dropt its clay coat, the poor, little animal being now light and agile, ſpends the reſt of its ſhort, winged ſtate, in friſking over the waters. During this the female being impregnated, drops her eggs upon the water. Theſe ſink to the bottom, where they are hatched by the heat of the ſun into little worms, which make themſelves caſes in the clay, and feed on the ſame, or on what the waters afford, without any need of parental care. Thus they are inhabitants of the water, till the time comes for ſhaking off their ſhell, and emerging into air.

Of one ſort of ephemeron, Mr. Collinſon writes thus. May 26, 1744. I was firſt ſhewn this, by the name of May-fly. It lies all the year, but a few days, at the bottom of a river; then riſes to the ſurface of the water, and ſplitting open its caſe, up ſprings the new animal, with a ſlender body, four ſhining wings, and three long hairs in its tail. It next flies about to find a proper place, where it may wait for its approach-

ing change. This comes in two or three days. I held one in my finger, while it performed this great work. It was ſurpriſing to ſee, how eaſily its back ſplit, and produced the new birth, which leaves head, body, wings, legs, and even its three-haired tail behind, or the caſes of them. After it has reſted a little, it flies nimbly to ſeek its mate. The males keep under the trees, remote from the river. Hither the females reſorted, and when impregnated, ſoon left the males, ſought the rivers, and kept continually plying up and down on the water. Every time they darted down, they ejected a cluſter of eggs. They then ſprang up again. Thus they went up and down, till they had exhauſted their ſtock of eggs and ſpent their ſtrength, being ſo weak that they can riſe no more, but fall a prey to the fiſh. This is the end of the females. The males never reſort to the river, but having done their office, drop down and die.

In a life of three or four days, they eat nothing. They have no apparatus for that purpoſe, yet they have ſtrength to ſhed their ſkin, and to perform the ends of their life with great vivacity.

But how poor an end, to our apprehenſion, is anſwered by the life of this, and innumerable other animals?

18. The eggs of butterflies do not increaſe in bulk while in the body of the female. As ſoon as they are impregnated by the male, they are ready to be laid. But this requires ſome time, both becauſe of their number, and the nicety with which ſhe arranges them. This indeed is the whole buſineſs of her life: for when they are laid, ſhe dies.

The female does not depoſit them at random, but ſearches out a ſort of plant which the caterpillars can feed on as ſoon as they are hatched. Neither does ſhe ſcatter them irregularly and without order, but diſpoſes them with perfect ſymmetry, and faſtens them together by a viſcous liquor diſcharged from her own entrails. And thoſe ſpecies whoſe hinder part is covered with long hairs, gradually throw them all off, and therewith make a neſt, wherein the eggs are kept ſafely, till the time of their hatching.

19. Some

19. Some caterpillars are hatched in the ſpring, as ſoon as the leaves they are to be fed on begin to bud. After thirteen days, they change into aurelia, and having paſt three weeks in that ſtate, they iſſue forth winged, with all the beauty of their parents.

The wings of butterflies fully diſtinguiſh them from flies of every other kind. They are four in number; and though two of them be cut off, the animal can fly with the two remaining. They are in their own ſubſiſtence tranſparent: but owe their opacity to the beautiful duſt with which they are covered, and which has been likened, by ſome, to the feathers of birds: by others, to the ſcales of fiſhes. In fact, if we regard the wing of a butterfly with a good microſcope, we ſhall perceive it ſtudded over with a variety of little grains of different dimenſions and forms, generally ſupported on a footſtalk, regularly laid upon the whole ſurface. Nothing can exceed the beautiful and regular arrangement of theſe little ſubſtances. Thoſe of one rank are a little covered by thoſe that follow: they are of many figures: here may be ſeen a ſucceſſion of oval ſtuds; there a cluſter of ſtuds, each in the form of a heart: in one place they reſemble a hand open; and in another, they are long or triangular; while all are interſperſed with taller ſtuds that grow between the reſt, like muſhrooms upon a ſtalk.

The eyes of butterflies have not all the ſame form, for in ſome they are large, in others ſmall. In all of them the outward coat has a luſtre, in which may be diſcovered the various colours of the rainbow. When examined cloſely, it will be found to have the appearance of a multiplying-glaſs: having a great number of ſides or facets, in the manner of a brilliant cut diamond. Theſe animals, therefore, ſee not only with great clearneſs, but view every object multiplied in a ſurpriſing manner. Puget adapted the cornea of a fly in ſuch a poſition, as to ſee objects through it by means of a microſcope; and nothing could exceed the ſtrangeneſs of its repreſentations: a ſoldier, who was ſeen through it, appeared like an army of pigmies; for while it multiplied, it alſo diminiſhed the object. It ſtill, however, remains a doubt, whether the inſect ſees objects ſingly, as with one eye; or whether every

facet

facet is itſelf a complete eye, exhibiting its own object diſtinct from all the reſt. The trunk, which few butterflies are without, is placed exactly between the eyes; which, when the animal is not ſeeking its nouriſhment, is rolled up like a curl. A butterfly, when it is feeding, flies round ſome flower, and ſettles upon it. The trunk is then uncurled, and thruſt out, ſearching the flower to its very bottom. This ſearch being repeated ſeven or eight times, the butterfly then paſſes to another; and continues to hover over thoſe agreeable to its taſte, like a bird over its prey. This trunk conſiſts of two hollow tubes, nicely joined like the pipes of an organ.

Butterflies as well as moths employ their ſhort lives in a variety of enjoyments. Their whole time is ſpent either in queſt of food, which every flower offers; or in purſuit of the female, whoſe approach they often perceive at above two miles diſtance. Their ſagacity in this particular is aſtoniſhing; but by what ſenſe they are capable of doing this, is not eaſy to conceive. It cannot be by ſight, ſince ſuch ſmall objects muſt be utterly imperceptible at half the diſtance: it can ſcarcely be by the ſenſe of ſmelling, ſince the animal has no organs for that purpoſe. Whatever be their powers of perception, certain it is, that the male, after having fluttered, as if careleſsly about, for ſome time, is ſeen to take wing and go forward, ſometimes for two miles together, in a direct line to where the female is perched on a flower.

Caterpillars are of no ſex, it not being their buſineſs to propagate, till they commence butterflies. Yet many of them are not ſo harmleſs as they ſeem; for they deſtroy their fellows whenever they can. Put twenty caterpillars of the oak together in a box, with a ſufficient quantity of leaves their natural food. Yet their numbers will decreaſe daily, till one only remains alive. The ſtronger ſeizes the weaker by the throat, and gives him a mortal wound. When he is dead, the murderer begins to eat him up, and leaves only the ſkin with the head and feet. But this is not the caſe of all. Many ſpecies live peaceably and comfortably together.

Yet

Yet even theſe are expoſed to dangers of a more terrible kind. The worms of ſeveral ſorts of flies continually prey upon them. Some are upon, ſome under the ſkin, and both eat up the poor, defenceleſs animal alive.

It is ſurpriſing to ſee with what induſtry theſe little creatures weave the caſes, in which they paſs their aurelia ſtate. Some are made of ſilk, mixt with their own hair, with pieces of bark, leaves, wood, or paper.

There is one ſort that builds in wood, and gives its caſe a hardneſs greater than that of the wood itſelf. This is the caterpillar of the willow, which is one of thoſe that eat their exuviæ. He has ſharp teeth, wherewith he cuts the wood into a number of ſmall fragments. Theſe he unites together into a caſe, by means of a peculiar ſilk, which is a viſcous juice that hardens as it dries. In order to make this ſilk enter into the very ſubſtance of the fragments, he moiſtens every one of them, by holding them ſucceſſively in his mouth for a conſiderable time. In this firm caſe he is afterward to be included till he becomes a butterfly. But how ſhall a creature of this helpleſs kind, which has neither legs to dig, nor teeth to gnaw, get out of ſo firm and ſtrong a lodgment as that wherein it is hatched? Nature has provided for this alſo. As ſoon as it is hatched, it diſcharges a liquor which diſſolves the viſcous matter that holds the caſe together, ſo that the fragments fall in pieces of themſelves. And accordingly, near its mouth, there is always found a bladder of the ſize of a ſmall pea, full of this liquor.

Some caterpillars ſpin, all the way they walk, a thread of ſilk which marks their journey. Now what end does this ſerve? A little obſervation will ſhew. Trace one of them till he chances to fall, and you will ſee the uſe of this thread. Being faſtened to the leaves and twiggs, it ſtops the creature's fall. Nor is this all. It can alſo by means of this thread, re-aſcend to the place from whence it fell. And when it is ſafe got up again, it continues its motion as before.

Another

Another curious artifice is that by which the ſame ſpecies of caterpillars make themſelves caſes of leaves before they change into aurelia. The niceſt hands could not roll theſe up ſo regularly, as they do without hands or any thing like them. They perform it thus. The caterpillar places itſelf on the upper ſide of the leaf, ſo far from the edge that he can reach it with his head. Turning himſelf round, he then brings the edge of the leaf to the point juſt oppoſite to it. It next draws lines from the edge of this leaf to that point; and doing this all the way along the leaf, its narrowneſs toward the point makes it form a cloſe caſe there. It ſtrengthens the firſt bending of the leaf, by many parallel threads, and then faſtening other threads to the back part of the leaf, draws them as tight as it can. The caſe is then formed. The ſame method repeated makes the additional caſes, five or ſix over each other. And every one of theſe is ſufficiently ſtrong, ſo as to make the inner ones uſeleſs. He then enters his cell, and undergoes his change. Meantime his covering ſerves him alſo for food. For ſo long as he has need to eat, he may feed upon the walls of his caſtle: all of which may be eaten away, except the outer one of all. Probably every caterpillar makes his caſe thick enough to ſerve the neceſſary calls of his future hunger.

Many ſpecies of butterflies lay a great number of eggs in the ſame place. Theſe all hatch very nearly at the ſame time. And one would naturally ſuppoſe, that the young brood of all, would be inclined to continue and live together. But it is not ſo: the different ſpecies have different inclinations. Some keep together from the time they are hatched, till they change into aurelia. Others ſeparate as ſoon as able to crawl, and hunt their fortune ſingle. And others live in community till a certain time, and then each ſhifts for itſelf. Thoſe that live wholly together, begin by forming a line with their little bodies upon a leaf; their heads all ſtanding even, and in this manner they move and eat together. And often there are ſeveral ranges of this ſort, which make ſo many phalanxes, and eat into the leaf they ſtand on, with perfect equality.

Many

Many do this while young, who when they grow large, make one common habitation, ſurrounded by a web, which is the joint work of all: within which, each has a neſt of its own ſpinning.

When they have made their common lodging, each takes its courſe over the tree or buſh for food. Thus many hundreds of them form a regular republic. The ſeparate cell of each, is finally the place where it paſſes its change into the aurelia and perfect ſtate. But many ſpecies do not ſeparate even then, but are found in their aurelia ſtate all huddled together; numbers of their caſes making one confuſed maſs.

One thing more is highly obſervable in them. The regularity of their marches. They are exactly obedient to their chief. When they change their quarters, one marches ſingle firſt; two others follow, and keep their bodies very nicely in the ſame poſition with his. After theſe there follows a large party. Theſe regulate their motions by the former: and ſo the order is continued through the whole company. When the leader turns to the right or left, the whole body does the ſame inſtantly. When he ſtops, they all immediately ſtop, and march again the moment he advances.

20. The outward covering of the body, is in many animals changed ſeveral times; but in few more frequently than the caterpillar. Moſt of theſe throw it off at leaſt once in ten days. Indeed in the whole inſect claſs, the moſt numerous of all animated beings, there is ſcarce one which does not caſt its ſkin, at leaſt once, before it arrives at its full growth. But the caterpillar changes more than his ſkin: even the outward covering of every, the minuteſt part of its body. And what they throw off has the appearance of a complete inſect, preſenting us with all the external parts of a living animal. If the caterpillar be of the hairy kind, the ſkin it throws off is hairy, containing the covering of every hair. And even the claws and other parts that are not viſible without a microſcope, are as plain in this as in the living animal. But what is more amazing is, that the ſolid parts of the head, the ſcull and teeth are diſtinguiſhable therein.

The throwing off an old ſcull and teeth, to make way for new ones, is an act beyond all comprehenſion! A day or two before, the creature refuſes to eat, and walks very ſlowly, or not at all. He turns from ſide to ſide, and often raiſes his beak, and gently depreſſes it again. He frequently raiſes his head, and ſtrikes it down rudely againſt any thing he ſtands upon. Frequently the fore-part of the body is raiſed from the place, and thruſt very briſkly backward and forward, three or four times together. There are likewiſe diſtinct motions within every ring. Theſe are ſeverally inflated and contracted alternately, by which the ſkin is looſened from them, till by this means, and its remaining without food, the body is quite diſengaged from its covering.

When this time approaches, all the colours of the ſkin grow faint, and loſe their beauty, receiving no nouriſhment from the body. And as the creature continues ſwelling and ſhrinking, the ſkin, being no longer ſupple, cracks along his back. The crack always begins at the ſecond or third ring from the head. As it opens, the new ſkin is ſeen within. This opening he eaſily enlarges, thruſting his body like a wedge, out of the ſlit, till he lengthens it thro' four rings. Then he has room to draw out the whole body. Firſt, the head is by ſeveral motions looſened, drawn out of the old ſkull, and raiſed through the crack: this is then laid ſoftly on the old ſkin of the part. By the ſame motions the tail end is diſengaged, drawn out, and laid ſmoothly on the old ſkin. It takes the animal ſeveral days, to prepare for the laſt operation. But when the crack is once made, the whole remaining work is done in leſs than a minute.

The hairs found on the caſt ſkins of the hairy caterpillars ſeem at firſt, like the other part of the exuviæ, to be only the covering of the hairs encloſed. But that is not the caſe. They are ſolid things themſelves, not barely coverings. In truth, the creature when firſt hatched, has all its ſkins perfectly formed, one under another, each furniſhed with its hairs, ſo that the old ones fall off with the old ſkins. And probably the erecting theſe is one great means of forcing off the old ſkins.

Perhaps

Perhaps the ſame ſort of mechaniſm is uſed even by thoſe caterpillars which do not appear to be hairy. For they really are ſo, as the microſcope ſhews. When the upper ſkin of one juſt ready to change, is ſlit longitudinally in the place where the crack would be, the ſkin may be taken off; and it is eaſily ſeen, how the new one lies below. The hairs are diſpoſed in the niceſt manner, for lying ſmooth under the upper ſkin. They grow in ſeparate tufts, which never lie one upon another, but together form one ſurface.

It is remarkable, that immediately after this change, they appear much larger than they did before. And they really are ſo. The very head and ſcull are greatly larger than before the change. The operation of the cray-fiſh in changing its ſhell, may explain this. This alſo is found conſiderably larger when out of the ſhell than before. In both caſes, the body had grown ſo much, that it was too big for its covering. However, while it remained in it, the parts were compreſſed, and forced to lie in that narrow room. But as ſoon as that covering is off, every part diſtends itſelf to its proper ſize.

Indeed, ſo large a ſcull, being a hard ſubſtance in the caterpillar, could not have been compreſſed into a ſmaller. But the fact is, the new ſcull never hardens till the change approaches, and then imperfectly. At the ſame time it neceſſarily takes, from the place it is in, an oblong form. In this ſhape it is found a few hours before the old ſkin is caſt off; not encloſed within it, but extended under the ſkin of the firſt ring of the body. When the old ſcull is thrown off, the new one ſoon hardens, and takes its proper figure.

We call the creature hatched from the egg of a butterfly, a caterpillar. But it is a real butterfly all that time. A caterpillar changes its ſkin four or five times, and when it throws off one, appears in another of the ſame form. But when it throws off the laſt, as it is now ſo perfect, as to need no farther nouriſhment, ſo there is no farther need of teeth, or any other parts of a caterpillar.

It is plain from hence, that the change of a caterpillar into an aurelia, is not the work of a moment, but is carrying on from the very time of its hatching

from

from the egg. But while the butterfly lies in the body of the caterpillar, its wings are long and narrow, and wound up into the form of a cord, and the feelers are rolled up on the head. The trunk alſo is twiſted up, and laid on the head, but in a very different manner from what it is in the perfect animal, or indeed in the aurelia.

A butterfly then in all its parts, is in the caterpillar in all its ſtates. But it is more eaſily traced, as it comes nearer the time of being changed into an aurelia. The very eggs hereafter to be laid by the butterfly, are to be found not only in the aurelia, but even in the caterpillar, all arranged in their natural, regular order. In the caterpillar indeed they are tranſparent: but in the aurelia they have their proper colour.

As ſoon as the limbs of the butterfly are fit to be expoſed to the more open air, they are thrown out from the body of the caterpillar, ſurrounded only with thin membranes. And as ſoon as they arrive at a proper degree of ſtrength and ſolidity, they break through theſe, and appear in their perfect form.

The animal then creeps a little on, and there reſts; the wings being quite folded up. But by degrees they expand, and in leſs than half an hour appear in all their beauty.

In the beginning of May, 1737, the cornel-trees near Monaghan in Ireland, appeared covered with ſmall caterpillars, employed partly in feeding on the leaves, partly in crawling over the bark of the tree. Each as it crawled left a fine thread ſticking to the bark. By the end of May, there was not a leaf on any of the trees, except a few reſerved for a curious purpoſe. But inſtead of the green, a white cloathing covered the whole bark, from the ground to the point of the ſmalleſt twigs, and that ſo gloſſy, that it ſhewed, in the ſun, as if it was caſed in burniſhed ſilver. Then they covered with the ſame all the aſh, beech, lime, yea the very weeds which grew near them.

But how did they travel from tree to tree? Many crawled along the ground. But many had a quicker way. They hung by their own threads from the utmoſt branches of the tree, ſo that a ſmall breeze wafted

wafted them to the next tree, as ſpiders paſs from one buſh to another.

As they made no uſe of the threads left behind them, probably they wrought for no other purpoſe, than to rid themſelves of that glutinous matter, out of which it was ſpun.

In the beginning of June, they retired to reſt. Their manner of executing this, was very ingenious. Some choſe the under ſide of the branches, juſt where they ſpring from the trunk, that they might be defended from the water, which in a ſhower, running down the bark of the tree, is parted by the branches, and ſent off on each ſide. Here they draw their threads acroſs the angle made by the trunk and branch; and croſſing thoſe with other threads, make a ſtrong covering. Within this they place themſelves lengthways among the threads, and rolling their bodies round, ſpin themſelves into little hammocks, in the mean time ſhrinking into half their length. Theſe hammocks being ſuſpended by the tranſverſe threads, do not preſs each other. That they may take up the leſs room, they lie parallel to each other, in the moſt convenient order poſſible. Others, ſtill more ingenious, faſten their threads to the edge of the leaves which they had ſaved for that purpoſe: and with that ſlender cordage pulling in the extremities of the leaves, draw themſelves into a kind of purſe, within which they form the ſame ſort of work, and lay themſelves up as above. They lay themſelves up in great numbers together, both becauſe many were neceſſary to the work of providing a common covering, and alſo to keep one another warm, while preparing for the great change.

Between the worm thus laid up, and the hammock encloſing it, there is a tough, brown ſhell, probably formed of ſome glutinous matter, tranſuding through its pores. In the end of June, they gnaw through the ſhells and hammocks, and come forth a moſt beautiful fly. After its reſurrection, it needs no food. Thoſe that came out in a room, lived as long there as the reſt did abroad. After awhile ſeveral of them diſcharged a drop of brown liquor, probably

bably containing the egg. But as it was not lodged in a proper receptacle, it produced no worm the next year.

As the cornel only ſupplies this worm with food, ſo it is the only nurſe of its egg. There is not an animal or a vegetable, but yields habitation and food to its peculiar inſect. The ſcheme of life begins in vegetation: and whenever nature produces vegetables, ſhe obliges them to pay for their nouriſhment, to certain animals which ſhe billets upon them. Each of theſe again, is to diet and lodge another ſet of living creatures. This juſt community in nature, which ſuffers nothing to ſubſiſt merely for itſelf, is found not only every where on the earth, but likewiſe every where in the waters. By microſcopes we diſcover an infinity of little creatures, feeding on the floating vegetables, or on one another. Indeed, as to the ſea, we know only what happens near the ſhores, where we find vegetables of various kinds, which breed and nouriſh a like variety of inſects. Theſe, with a multitude of others bred in the mud, are the prey of the ſmaller kinds of fiſh, and they again of a greater. That this ſcheme of nature, found every where elſe, dives into the depths of the ocean, we may gather from the wonderful kind of fiſhes, waſhed up by the ſtorms now and then from the deep waters.

Now it is on the cornel alone, that the worms we have ſpoken of can be propagated and fed. The ſpecific qualities with which its juices are impregnated, are peculiarly ſuitable to this inſect. If theſe reſide in the eſſential oil of the plant, this, as well as the other inſects, ſubſiſting on vegetables, have the ſkill to extract, nicer than any chemiſt can do, the eſſential oil of each plant, nothing elſe therein, being of a nature ſufficiently peculiar, either to aſſiſt the propagation, or ſupply the nouriſhment of the inſect.

21. The ant lays eggs like flies, from which are hatched ſmall worms without legs. Theſe are ſharp at one end, and blunt at the other: after a ſhort time they change into a large, white aurelia, vulgarly called ants-eggs: whereas they are larger than the ants themſelves.

themſelves. They move theſe at their pleaſure. When an ant's neſt is diſturbed, and the aurelia ſcattered abroad, the ants are at infinite pains to gather them and make them a neſt again. Nay, thoſe of one neſt will often do this for the aurelia of another.

At the bottom of an ant's neſt, which is built with ſmall pieces of dry earth, there is always a large quantity of eggs, worms, and aurelia. The aurelia are covered only with a thin ſkin, and if opened, ſhew the ant in its ſeveral ſtages toward perfection.

In every neſt, as in every bee-hive, there are three kinds of the inſect, males, females, and working ants, or labourers. Theſe laſt are neither male nor female, nor have any buſineſs, but taking care of the young brood. Male ants have four wings, and three lucid points on their head, and their eyes are larger than thoſe of the female or labourers. They are not found in the neſts at all ſeaſons, but only at particular times. It ſeems they are killed (like drone bees) as ſoon as the ſeaſon for impregnating the females is over.

The body of the female is larger and thicker than that of the male, or labourer; and contains a great number of eggs, placed in regular lines. She has alſo the three lucid points on her head, which ſeem to be three eyes.

The ant examined by the microſcope, appears a very beautiful creature. Its head is adorned with two horns, each having twelve points. Its jaws are indented with ſeven little teeth, which exactly tally. They open ſideways exceeding wide, by which means the ant is often ſeen graſping and carrying away bodies of three times its own bulk. It is naturally divided into the head, the breaſt, and the belly, each joined to the other by a ſlender ligament. From the breaſt proceed three legs on each ſide. The whole body is caſed over with a ſort of armour, ſo hard as ſcarce to be penetrated by a lancet, and thick ſet with ſhining, whitiſh briſtles.

They bring out, not corn, but their young, every day, and ſpread them near their neſt, in little heaps, on a kind of dry earth, provided for that purpoſe. They carry them back at night. But it is obſerved, they never bring them out, unleſs in a day that promiſes

miſes to be fair. In the prognoſtics of this they ſhew great ſagacity. Where it is dangerous to expoſe them in the day time, by reaſon of the birds, they vary their rule, bringing them out in the night, and carrying them back in the morning.

They do not eat at all in winter, but ſleep like moſt other inſects. There is a ſtrait hole in every ant's neſt, about half an inch deep; after which it goes ſloping into their magazine, which is a different place from that where they eat and reſt. Over the hole they lay a flat ſtone or tile, to ſecure them from their great enemy the rain. In a fair day, the whole is open; but when they foreſee it will rain, and every night, the cover is drawn over, with great ingenuity as well as labour. Fifty of the ſtrongeſt of them ſurround the ſtone, and draw and ſhove in concert. The like pains they take every morning, to thruſt it back again.

An ant never goes into any neſt but her own; if ſhe did, ſhe would be ſeverely puniſhed. And if ſhe returned again after this warning, the others would tear her in pieces. Therefore they never attempt it, but in the laſt extremity: ſometimes they will rather ſuffer themſelves to be taken.

Ants do not bite, as is vulgarly ſuppoſed, But red ants have a ſting, which expreſſes a corroſive liquor, that raiſes a ſlight inflammation. The black ants have no ſting.

On opening an ant-hill, a great quantity of eggs, is uſually found. They look like the ſcatterings of fine ſalt, and are too minute to be ſeen diſtinctly by the naked eye. Through a microſcope they appear like the eggs of ſmall birds, and are as clear as the air-bladder of fiſhes. They lie in cluſters under cover of ſome light earth. The ants ſeem to brood over them, till every granule is hatched into a worm, not much larger than a mite. In a ſhort time theſe turn yellowiſh and hairy, and grow to near as big as their parent. They then get a whitiſh film over them, and are of an oval form. If this cover be opened after ſome days, all the lineaments of an ant may be traced; though the whole is tranſparent, except the eyes, which are two dark ſpecks.

The care theſe creatures take of their young is amazing.

amazing. Whenever a hill is diſturbed, all the ants are found buſy, in conſulting the ſafety, not of themſelves, but of their offspring. They carry them out of ſight as ſoon as poſſible; and will do it over and over, as often as they are diſturbed. They carry the eggs and worms together in their haſte; but as ſoon as the danger is over, they carefully ſeparate them, and place each by themſelves, under ſhelter of different kinds, and at various depths, according to the different degrees of warmth which their different ſtates require.

In the ſummer they every morning bring up the aurelia near the ſurface of the earth. And from ten in the morning till about five in the afternoon, they may be found juſt under the ſurface. But if you ſearch at eight in the evening they will be found to have carried them all down. And if rainy weather be coming on, they lodge them at leaſt a foot deep.

Though ants unite in colonies, in ſuch places as are agreeable to their different natures, yet they often vary their reſidence. But the ſeveral ſpecies never intermix, though they will be good neighbours one to another.

Their architecture is adjuſted with remarkable art. The whole ſtructure is divided into numerous cells, communicating with each other by ſmall ſubterraneous channels, which are circular and ſmooth. They carry on all their works by means of their double ſaws, and the hooks at the extremity of them.

A colony from the latter end of Auguſt to the beginning of June, conſiſts of a female, and various companies of workers: and beſides theſe in the latter end of June, all July and part of Auguſt, of a number of winged ants.

The labouring ants, being of no ſex, are wholly employed in providing for the young, which the queen depoſits in the cells. In whatever apartment ſhe is preſent, univerſal joy is ſhewn. They have a particular way of ſkipping, leaping, prancing, and ſtanding on their hind legs. Some walk gently over her, others dance round her, all expreſs their loyalty and affection; of all which you may be convinced in a few moments, by placing the queen and her retinue under a glaſs.

The

The queen lays three different ſorts of eggs, male and female in ſpring, neutral in July and part of Auguſt. The common ants then brood over them in little cluſters, and remove them to and fro, for a juſt degree of heat. The young diſengage themſelves from the membranes that encloſe the eggs, juſt as the ſilk-worms do. The female eggs put on the form of worms, ſome time in February; the male, by the latter end of March, the neutral by September. The firſt ſummer they grow little, and leſs in winter. In the beginning of April the ſecond year, they viſibly increaſe every day. By the end of May the male and female attain their full growth, and are ready for another change. This long continuance of ants in the vermicular ſtate, has nothing like it in any other claſs of inſects. The vermicles in a few days infold themſelves in a ſoft ſilken covering, and ſo commence aurelias, which are commonly miſtaken for ants eggs. As ſoon as they tend to life, the workers give them air, by an aperture in the end of the covering. This they gradually enlarge for a day or two, and then take out their young.

There is a larger and a ſmaller ſort of winged ants, the latter male, the former female. Thoſe females which eſcape being devoured by other creatures, become queens, and give birth to new colonies.

In all other inſects the loſs of their wings leſſens their beauty, and ſhortens their lives. But ants gain by that loſs: this being the prelude of their aſcending the throne.

The young are fed by the juices of moſt ſorts of fruits, which the labourers extract, and receive into their own ſtomach; where they are prepared, and afterwards transfuſed into the tender vermicles.

Perhaps in warm climates, ants do not paſs the winter in ſleep, as they do with us. If ſo, they need a ſtore of food, which in our climate is quite needleſs. Accordingly, thoſe who have accurately examined their moſt numerous ſettlements, could never find out any reſervoir of corn or other aliments. And they that have carefully obſerved their excurſions from and return to their colonies, could never obſerve that they returned with any wheat corn, or any other vegetable ſeed:

though

though they would eagerly attack a pot of honey, or a jar of ſweet-meats.

But is it not ſaid, Prov. vi. 8. "She provideth her meat in the ſummer, and gathereth her food in the harveſt?" It is: but this does not neceſſarily mean any more, than that ſhe collects her food in the proper ſeaſon. Nor is any thing more declared, ch. xxx. 35, than that ants carry food into their repoſitories. That they do this againſt winter, is not ſaid: neither is it true in fact.

In England ant-hills are formed with but little apparent regularity. In the ſouthern provinces of Europe, they are conſtructed with wonderful contrivance. They are generally formed in the neighbourhood of ſome large tree and a ſtream of water. The one is the proper place for getting food; the other for ſupplying the animals with moiſture, which they cannot well diſpenſe with. The ſhape of the ant-hill is that of a ſugar-loaf, about three feet high, compoſed of various ſubſtances; leaves, bits of wood, ſand, earth, bits of gum, and grains of corn. Theſe are all united into a compact body, perforated with galleries down to the bottom, and winding ways within the ſtructure. From this retreat to the water, as well as to the tree, in different directions, there are many paths worn by conſtant aſſiduity, and along theſe the buſy inſects paſs and repaſs continually; ſo that from May or the beginning of June they work continually till the bad weather comes on.

The chief employment of working ants is in finding a ſufficiency of food. They live upon various proviſions, as well of the vegetable as the animal kind. Small inſects they kill and devour; ſweets of all kinds they are particularly fond of. They ſeldom, however, think of their community till themſelves are firſt ſatiated. Having found a juicy fruit, they ſwallow what they can, and then tearing it in pieces, carry home their load. If they meet with an inſect above their match, ſeveral of them will fall upon it at once, and having torn it to pieces, each will carry off a part of the ſpoil. If they meet with any thing that is too heavy for one to bear, and yet which they are unable to divide, ſeveral of them endeavour to force it along,

ſome

ſome dragging, others puſhing. If any one of them makes a lucky diſcovery, it immediately gives advice to others, and then at once, the whole republic put themſelves in motion. If in theſe ſtruggles one of them happens to be killed, ſome ſurvivor carries him off to a great diſtance, to prevent the obſtructions his body might give to the general ſpirit of induſtry.

In autumn they prepare for the ſeverity of the winter, and bury their wheat as deep in the earth as they can. It is now found that the grains of corn, and other ſubſtances with which they furniſh their hill, are only meant as fences to keep off the rigour of the weather. They paſs four or five months without taking any nouriſhment, and ſeem to be dead all that time. It would be to no purpoſe therefore for ants to lay up corn for the winter, ſince they lie that time without motion, heaped upon each other, and are ſo far from eating, that they are utterly unable to ſtir. Thus what authors have dignified by the name of a magazine, appears to be no more than a cavity, which ſerves for a common retreat, when they return to their lethargic ſtate.

But what has been falſely ſaid of the European ant, is true of thoſe of the tropical climates. They do lay up proviſions, and as they probably live the whole year, ſubmit to regulations unknown among the ants in Europe. Thoſe of Africa are of three kinds, the red, the green, and the black; the latter are above an inch long, and in every reſpect, a moſt formidable inſect. They build an ant-hill from ſix to twelve feet high: made of viſcous clay, and in a pyramid form. The cells are ſo numerous and even, that a honey-comb ſcarce exceeds them. The inhabitants of this edifice ſeem to be under a very ſtrict regulation. At the ſlighteſt warning they ſally out upon whatever diſturbs them; and if they arreſt their enemy, he is ſure to find no mercy. Sheep, hens, and even rats are often deſtroyed by theſe mercileſs inſects, and their fleſh devoured to the bone. No anatomiſt can ſtrip a ſkeleton ſo clean as they.

If a frog be put into a box with holes bored therein, and the box laid near a neſt of ants, they will entirely diſſect him, and make the fineſt ſkeleton poſſible, leaving even the ligaments unhurt.

22. One

22. One of the moſt dreadful enemies of the ant is the formica-leo or ant-eater: it is ſoft as a ſpider, but has in its form ſome reſemblance of a wood-louſe. Its body is compoſed of ſeveral rings: it has ſix legs, four joined to the breaſt; and the other two to a long part, which may be termed the neck. Its head is ſmall and flat, and it has two remarkable horns, the ſixth of an inch long, as thick as a hair, hard, hollow and hooked at the end. At the origin of each of theſe horns, it has a clear and bright black eye.

He is not able to hunt after prey, nor to deſtroy large inſects. He can only enſnare ſuch as come by his habitation, and of theſe, few are ſuch as he can manage. All the winged tribe eſcape by flight, and thoſe that have hard ſhells are of no uſe to him. The ſmallneſs of the ant, and its want of wings, make it his deſtined prey. The manner wherein he proceeds is this. He uſually encamps under an old wall for ſhelter, and always chuſes a place where the ſoil is compoſed of a light, dry ſand. In this he makes a pit in the ſhape of a funnel, which he does in the following manner.

If he intends the pit to be but ſmall, he thruſts his hinder parts into the ſand, and by degrees works himſelf into it. When he is deep enough, he toſſes out with his head the looſe ſand which is run down, artfully throwing it off, beyond the edges of the pit. Then he lies at the bottom of the ſmall hollow, which comes ſloping down to his body.

But if he is to make a larger pit, he firſt traces a larger circle in the ſand. Then he buries himſelf in it, and carefully throws off the ſand, beyond the circle. Thus he continues running down backward, in a ſpiral line, and throwing off the ſand above him all the way, till he comes to the point of the hollow cone, which he has formed by his paſſage. The length of his neck, and the flatneſs of his head, enable him to uſe the whole as a ſpade. And his ſtrength is ſo great that he can throw a quantity of ſand, to ſix inches diſtance. He likewiſe throws away the remains of the animals he has devoured, that they may not fright other creatures of the ſame ſpecies.

Where the ſand is unmixed, he makes and repairs his pit with great eaſe. But it is not ſo where other ſubſtances

ſtances are mixed with it. If when he has half formed his pit, he comes to a ſtone not too large, he goes on leaving that to the laſt. When the pit is finiſhed, he creeps up backwards to the ſtone, and getting his backſide under it, takes great pains to get it on a true poiſe, and then creeps backwards with it, to the top of the pit.

We may often ſee one thus labouring at a ſtone four times as big as his own body. And as it can only move backward and the poiſe is hard to keep, eſpecially up a ſlope of crumbly ſand, the ſtone frequently ſlips when near the verge, and rolls down to the bottom. In this caſe he attacks it again, and is not diſcouraged by five or ſix miſcarriages; but attempts it again, till at length he gets it over the verge of his place. Yet he does not leave it there, leſt it ſhould roll in again, but always removes it to a convenient diſtance.

When his pit is finiſhed, he buries himſelf at the bottom of it in the ſand, leaving no part above it, but the tips of his horns, which he extends to the two ſides of the pit. Thus he waits for his prey. If an ant walk on the edge of his pit, it throws down a little of the ſand. This gives notice, to toſs up the ſand from his head, on the ant; of which he throws more and more, till he brings him down to the bottom, between his horns. Theſe he then plunges into the ant, and having ſucked all the blood, throws out the ſkin as far as poſſible. This done, he mounts up the edges of his pit, and if they have ſuffered any injury, repairs it carefully. He then immediately buries himſelf again in the centre, to wait for another meal.

This creature has no mouth, but it is through its horns that it receives all its nouriſhment. And as they are ſo neceſſary for its life, nature has provided for the reſtoring them, in caſe of accidents: ſo that if they are cut off, they ſoon grow again.

When he has lived his ſtated time, he leaves his pit, and is only ſeen drawing traces on the ſand. After this he buries himſelf under it, and encloſes himſelf in a caſe. This is made of a ſort of ſilk with grains of ſand cemented together by a glutinous humour which he emits. But this would be too harſh for his body:

ſo

ſo it ſerves only for the outward covering. He ſpins within it one of pure, fine, pearl-coloured ſilk, which covers his whole body. When he has lain ſome time in this caſe, he throws off his outer ſkin, with the eyes, the horns, and all other exterior parts, and becomes an oblong worm, in which may be traced the form of the future fly. Through its tranſparent ſkin may be ſeen new eyes, new horns, and all other parts of the perfect animal. This worm makes its way about half out of the caſe, and ſo remains, without farther life or motion, till the perfect fly makes it way out of a ſlit in the back. It much reſembles the dragon-fly. The male then couples with the female and dies.

23. The ſegacity of bees, in making their combs, cannot be too much admired. The labour is diſtributed regularly among them. The ſame bees, ſometimes carry the wax in their jaws, and moiſten it with a liquor which they diſtil upon it, and ſometimes build the walls of their cells. But they that form the cells, never poliſh them. Others make the angles exact, and ſmooth the ſurface. The bits of wax which are ſcraped off in doing this, others pick up, that none may be loſt.

Thoſe that poliſh, work longer than thoſe that build the walls; poliſhing not being ſo laborious a work as building. They begin the comb at the top of the hive, faſtening it to the moſt ſolid part thereof. Hence they continue it from top to bottom, and from ſide to ſide. The cells are always ſix ſided: a figure which, beſide the advantage it has in common with the ſquare, of leaving no vacancies between the cells, has this peculiar to itſelf, that it includes a greater ſpace within the ſame ſurface than any other figure.

It is a grand queſtion, Is there any part of a plant without iron? It is certain honey is not. And if ſo delicate an extract from the fineſt part of flowers, and that farther elaborated in the bowels of the inſect: if this be not without iron we may deſpair of ſeeing any part ſo.

The trunk of a working bee, is not formed in the manner of a tube by which the fluid is to be ſucked up; but like a beſom to ſweep, or a tongue to lick it away.

away. The animal is furniſhed alſo with teeth, which ſerve in making wax. This ſubſtance is gathered from flowers like honey: it conſiſts of that duſt or farina which contributes to the formation of plants. Every bee when it collects this, enters into the cup of the flower, particularly ſuch as have the greateſt quantity of this yellow farina. As the animal's body is covered over with hair, it rolls itſelf within the flower, and is ſoon covered over with duſt, which it bruſhes off with its two hind legs, and kneads into two little balls.

The habitation of bees ought to be very cloſe; and what their hives want, from the negligence or unſkilfulneſs of man they ſupply by their own induſtry: ſo that it is their principal care, when firſt hived, to ſtop up all the crannies. For this purpoſe they make uſe of a reſinous gum, which is more tenacious than wax. When they begin to work with it, it is ſoft, but it acquires a firmer conſiſtence every day. The bees carry it on their hinder legs, and plaiſter the inſide of their hives therewith. Their teeth are the inſtruments by which they model and faſhion their various buildings, and give them ſuch ſymmetry. Several of them work at a time, at the cells which have two faces. If they are ſtinted in time, they give the new cells but half the depth, which they ought to have; leaving them imperfect, till they have ſketched out the cells neceſſary for the preſent occaſion. The conſtruction of their combs, coſts them a great deal of labour: they are made by inſenſible additions, and not caſt at once into a mould as ſome are apt to imagine. There ſeems no end of their ſhaping, finiſhing, and turning them neatly up. The cells for their young are moſt carefully formed; thoſe deſigned for drones, are larger than the reſt, and that for the queen bee, the largeſt of all. Honey is not the only food on which they ſubſiſt. The meal of flowers is one of their favourite repaſts. This is a diet which they live upon during the ſummer, and of which they lay up a large winter proviſion. The wax is no more than this meal digeſted and wrought into a paſte. When the flowers are not fully blown, and this meal is not offered in ſufficient quantities, the bees pinch the tops of the ſtamina in

which

which it is contained, with their teeth; and thus anticipate the progreſs of vegetation. In April and May the bees are buſy from morning to evening, in gathering this meal: but when the weather becomes too hot, they work only in the morning. The bee is furniſhed with a ſtomach for its wax, as well as for its honey. In the former their powder is altered, digeſted, and concocted into wax; and is then ejected by the ſame paſſage by which it was ſwallowed. Beſide, the wax thus digeſted, there is a large portion of the powder kneaded up for food in every hive, and kept in ſeparate cells for winter proviſion. This is called by the country people bee-bread; and contributes to the health and ſtrength of the bee during the winter. We may rob them of their honey, and feed them during the winter with treacle, but no proper ſubſtitute has yet been found for the bee-bread; without it the animal becomes conſumptive and dies.

Honey is extracted from that part of the flowers called the nectareum. From the mouth it paſſes into the firſt ſtomach, or honey-bag, which when filled, appears like an oblong bladder. When a bee has filled its firſt ſtomach, it returns back to the hive, where it diſgorges the honey into one of the cells. It often happens that the bee delivers its ſtore to ſome other at the mouth of the hive, and flies off for a freſh ſupply. Some honey-combs are left open for common uſe, many others are ſtopped up, till there is a neceſſity of opening them. Each of theſe are covered carefully with wax; ſo cloſe that the cover ſeems to be made at the very inſtant the fluid is depoſited within them.

It was formerly thought that bees do not collect honey in the form we ſee it, but lodge it in their ſtomachs, till its nature is changed. But we now know that they merely collect it. Many flowers afford it; but beſide this, there are two kinds of honey dews. The one does not fall, but is a mild ſweet juice, which having circulated in the veſſels of plants, is ſeparated by proper ſtrainers, and exſudes on the leaves, though ſometimes it is depoſited on the pith, or in the ſugar canes.

So the leaves of the holm-oak are frequently covered with thouſands of ſmall drops, which point out

the ſeveral pores from which they proceeded, and are no other than pure honey. But it is found only on the old leaves, which are ſtrong and firm, not on the tender ones, which are newly come forth: although the old are covered by the new ones, and ſo ſheltered from any thing, that could fall from above. Mean time the leaves of the neighbouring trees, have no moiſture upon them: whereas, if it falls as a dew, it would neceſſarily wet all the leaves without diſtinction.

The other kind of honey-dew, ſprings from a ſmall inſect called a vine-fretter: the excrement of which is the moſt delicate honey in nature. They ſettle on branches of trees that are a year old; the juice of which, however harſh at firſt, becomes in the bowels of the inſect equal in ſweetneſs to any honey whatever.

There are two ſpecies of theſe flies, the ſmaller is green; the other, twice as large, is blackiſh. Hearing many bees buzzing in a tuft of a holm-oak, upon obſerving, I found the tuft of leaves and branches covered with drops which the bees collected. Each of the drops was not round, but of a longiſh oval. I ſoon perceived from whence they proceeded. The leaves covered with them, were juſt beneath a ſwarm of the larger vine-fretters; which from time to time raiſed their bellies, and ejected ſmall drops of an amber colour. I catched ſome of them on my hand, and found they had the very ſame flavour with what had before fallen on the leaves. I afterwards ſaw the ſmaller vine-fretters eject their drops in the ſame manner. This is the only honey dew that falls: and this never falls from a greater height than a branch, where a cluſter of theſe inſects can fix themſelves.

Ants are as fond of this honey as bees. The large black ants follow the inſect which lives on oaks and cheſnut-trees; the leſſer attend thoſe on the elder. But as ants cannot ſuck up fluids like bees, they wait juſt under the vine-fretters, in order to ſuck the drop juſt as it falls.

The vine-fretters afford moſt honey about midſummer, as the trees are then fulleſt of juice. The trees nevertheleſs, though pierced to the ſap in a thouſand places, do not ſeem to be hurt at all.

The ſting of a bee or waſp is a curious piece of workmanſhip,

workmanſhip. It is a hollow tube, within which, as in a ſheath, are two ſharp bearded ſpears. A waſp's ſting has eight beards on the ſide of each ſpear, ſomewhat like the beards of fiſh-hooks. Theſe ſpears in the ſheath, lie one with its point a little before that of the other. One is firſt darted into the fleſh, which being fixed, by means of its foremoſt beard, the other ſtrikes in too, and ſo they alternately pierce deeper, the beards taking more and more hold in the fleſh: afterward the ſheath follows, to convey the poiſon into the wound. When the beards are lodged deep in the fleſh. Bees often leave their ſtings behind them, if they are diſturbed before they have time to withdraw their ſpears into the ſcabbard.

The queen-bee is ſomewhat larger, conſiderably longer, and of a brighter red than others. Her office is, to direct, and lead the ſwarm, and to raiſe a new breed. She brings forth ten, fifteen, or twenty thouſand young ones in a year: ſo that ſhe may literally be ſaid, to be the mother of her people. In a hive of eight or ten thouſand, there is uſually but one queen-bee.

Drones, or males have no ſtings, and are larger and darker-coloured than the working bees. The eggs for them are placed in a larger ſort of cells. They are alſo nurſes to the young brood.

It is certain bees foreſee rain, though we know not how. Hence no bee is ever caught in a ſudden ſhower: unleſs it be far diſtant from the hive, or any way hurt or ſickly.

Thus much may be ſeen on the outſide of the hive. But when we look within, how is the wonder increaſed! to ſee ſo many thouſands all ſo buſily at work, and with ſuch admirable regularity! Nor is there leſs wonder in obſerving the cluſters of them, when they take ſome reſt. Their method then is, to get together and hang one to another in vaſt numbers. When theſe cluſters are large, they are only ſhapeleſs heaps; when ſmaller they are a ſort of feſtoon or garland, each end being faſtened to the branch, and the middle dropping from it. The manner in which they hang is this. Each with one or both of his fore-legs lays hold of one or both of the hinder-legs of the bee that is next above it.

Through a glaſs hive we ſee, that as the combs are carried down from the top to the bottom of the hive, each is placed parallel to the former, but not touching it, there being a ſpace between for the bees to walk. Theſe are the public ſtreets, and by means of theſe they can make uſe of every cell. There are likewiſe alleys cut from ſtreet to ſtreet, through the ſubſtance of the ſeveral combs.

All the cells are uſed in common. Some of them contain only honey, and are covered with a lid of wax. Theſe are never touched by any bee. But other cells are open, and a bee is often ſeen ſo lodged in one of theſe, that only its hinder part appears. The meaning hereof is, each of theſe open cells contains at the bottom a bee-worm. Certain bees daily viſit theſe, plunging their heads into the ſeveral cells, one after another.

The fruitfulneſs of the female is the leſs ſtrange, when we conſider the number of the males. In any hive there are, at the ſeaſon, ſeveral hundreds: in ſome two or three thouſand. Theſe are the joint fathers of the numerous offſpring, and when they have done their work, are all killed. The wings of the female reach only to the third ring of her body; whereas thoſe of all other bees cover the whole body. But though ſhe is thus eaſy to be diſtinguiſhed, yet few have ever ſeen a queen-bee: as ſhe is always cloſe covered in the hive.

Mr. Reaumur, deſiring to try how far the accounts given of the homage paid by others to the queen-bee was true, cauſed a ſwarm of bees to be ſwept down into a glaſs hive. Among theſe there was one female. She was ſoon diſtinguiſhed by her ſhape, and the ſhortneſs of her wings. For awhile ſhe walked alone at the bottom of the hive; the reſt ſeeming to regard nothing but their own ſafety. The female after going twice or thrice up the ſide of the hive, to the top of it, where they were hung, at laſt going in among the cluſter, brought down about a dozen with her. Attended with theſe, ſhe walked along ſlowly at the bottom of the hive. But the reſt continuing at the top, ſhe went again and again, till they all came down and formed a circle about her, leaving her a free paſſage

wherever

wherever ſhe turned to walk, and feeding her with the honey they had gathered for themſelves.

The hive was large enough for more than their number. However the female ſeemed to find, it would not be large enough for the family ſhe was to produce. So gathering them all about her, ſhe went out and flew to a neighbouring tree. All followed her, and formed a cluſter about her in the common way.

The bees follow their queen wherever ſhe goes. And if ſhe be tied by one of the legs to a ſtick, all the ſwarm will gather in a cluſter about her, and by removing the ſtick may be carried any where.

Nature ſeems to have informed the common bees, that they are to bring up the offſpring of this female, therefore they ſerve her in every thing. If by any means ſhe is dirtied, all the reſt try who ſhall clean her. And in cold weather they cluſter together about her to keep her warm. Nor do they ſhew this reſpect to one female only. Mr. Reaumur, at ſeveral times, put ſeveral females marked with different colours, into the ſame ſwarm. And all theſe were, for a time, received as well as the proper female.

The ſwarm which leaves an old hive, have often three or more females. Theſe have their ſeveral followers. And each with her followers, were the number ſufficient, would form a diſtinct ſwarm. As it is not, they all go into the ſame hive. But all, except one, are ſoon deſtroyed. The reaſon is, the working bees of a hive have enough to do to prepare cells, for lodging the eggs of one female, and it would be impoſſible for them to prepare twice or thrice that number.

Sometimes in two parts of a ſwarm, there are more than two female bees. In this caſe too, as ſoon as they are lodged in the hive, all are killed but one. Nature deſigns but one female for each ſwarm. But as many things may deſtroy the egg or worm of this ſingle female, it was needful, that proviſion ſhould be made for accidents. So that there are often twenty females which live to maturity with the bees of one ſwarm. But one only is then ſpared, whether they go out of the ſwarm, or remain within.

As

As ſoon as the ſwarm is gone out, the firſt work of the remaining bees, is to deſtroy the young females. Theſe are all immediately killed and carried out of the hive; and it is common, the morning after the going out of a ſwarm, to ſee ſix, eight, or more female bees, lying dead at ſome diſtance from the hive. What determines the bees in favour of one, is her having eggs ready to be hatched. Accordingly, if new made cells be examined, ſhe will be found the very next day, to have laid eggs in many, if not all. Whereas if the bodies of the rejected females be examined, there will be found either no eggs at all, or eggs ſo extremely minute, that it muſt have been a long time before any could have been laid.

It is not at all times, however, that the bees are thus cruel to the ſupernumerary females; but only at the time when they are newly eſtabliſhed in their habitation, and in want of all things. At other times they are as kind to ſtrange females as to their own. Mr. Reaumur tried the experiment, by putting a ſtrange female into a hive, where the combs were perfect, and filled with honey. And the bees ſhewed the ſame reſpect to her, as to their proper ſovereign.

The bee that comes loaded to any cell, ſoon diſcharges his honey into it. No ſooner is he gone, than another comes, and ſo on, till the whole cell is filled. But that which lies uppermoſt is always of a different appearance from the reſt of the honey. It is a kind of cream, which both keeps the honey moiſt, and prevents its running out by accident.

This cruſt or cream was not, as one would think, voided laſt, but was gathering from the firſt. For the bee which comes loaded to the cell, does not at once diſcharge his honey, but entering into it as deep as may be, thruſts out his fore-legs, and pierces a hole through the cruſt. Keeping this open with his feet, he diſgorges the honey in large drops from his mouth. He then cloſes the hole, and this is regularly done by every bee that contributes to the common ſtore.

But every bee that comes loaded to the hive, does not depoſit his honey in the cell. They often diſpoſe of it by the way. Inſtead of going to any cell, they often

often go to thoſe that are at work, and call them to feed upon the honey they have brought, that they may not be obliged to intermit their work, on account of hunger. Theſe feed on the ſtore of the friendly bee, by putting their trunk into her mouth, exactly in the ſame manner as they do into the bottom of flowers.

Some cells in every hive contain honey for immediate conſumption, as in caſe of bad weather. And theſe are always open at the top. Others contain their proviſion for the winter. Theſe are all cloſed down with a ſtrong lid, not eaſily to be removed. Such is the wiſdom which the great Author of Nature has imparted to ſome of the moſt inconſiderable of his creatures.

24 The kind of ſea-ſhrubs, as they were formerly accounted, uſually termed corallines, are in reality no other than caſes for various ſpecies of inſects. A French gentleman was the firſt who diſcovered this. Obſerving a great number of inſects lodged in ſeveral parts of theſe marine productions, he ſoon inferred, that theſe were only caſes made by theſe creatures for their habitations: and many of them have ſince been found to be the covers of marine polypi: a ſtrange kind of animal, ſo nearly partaking of the nature of ſome vegetables, that new, perfect polypi, perpetually grow like branches from the trunk of the parent. Yea, if a polypus be cut in pieces, every piece will grow into a perfect polypi.

A late writer informs us, "At the iſle of Sheppey, I had the opportunity of ſeeing ſeveral branched corallines, alive in ſea-water, by the help of a commodious microſcope, and was fully aſſured, that theſe apparent plants were real animals, in their proper caſes, which were fixed to the ſhells of oyſters and other ſmall ſhellfiſh. And at Brighthelmſtone, I ſaw thoſe corallines in motion, whoſe polypi are contained in cups ſupported by a long ſtem that appears full of rings, or twiſted in form of a ſcrew. In the middle of the tranſparent ſtems or caſes, I could eaſily diſcern the thread like a tender part of the animals. On ſeveral parts of theſe corallines there are little bodies, which through the microſcope appear as ſo many bladders. To the uſe

of

of theſe I was quite a ſtranger before: but I now diſcovered, they are habitations of young polypes, which are produced here and there on the ſides of the parent, as in the freſh-water polypus; only in the marine ones they are protected by this veſicular covering. Theſe veſicles appear at a certain ſeaſon of the year, according to the different ſpecies of corallines, and fall off, like the bloſſoms of plants, as ſoon as the polypi arrive at maturity.

But corallines are caſes, not of polypes only, but of various ſorts of animals: which occaſion their being made of various materials, and in great variety of forms. Some are united cloſely and compactly together, forming irregular branches, like trees. Others riſe in tufts, like the tubular ſort of plants, diſtinct from one another. Some Malteſe Corallines are of a peculiar kind. The animals encloſed in theſe, reſemble the many-legged ſpiders, uſually known by the name of ſcolopendræ. Their outſide coats are formed of an aſh-coloured earthly matter, and cloſely united to an inner coat, which is tough, horny, tranſparent, and extremely ſmooth. The cavity of the tube is quite round, though the animal is of a long figure, like a leech extended. It can turn itſelf in this tube, and move up and down, the better to attack and ſecure its prey.

It has two remarkable arms. The left much larger than the right. Theſe are doubly feathered. The number of its feet on each ſide of the body, exceeds a hundred and fifty.

As barnacles ſeem to be a medium between birds and fiſhes, although they more properly belong to the former, ſo is a polypus, (although it is doubtleſs an animal) between animals and plants.

In a polypus, life is preſerved, after it is cut into ſeveral pieces, ſo that one animal is by ſection immediately divided into two, three, or more complete animals, each enjoying life, and continuing to perform the proper offices of its ſpecies.

The common operations both of the animal and vegetable world, are all in themſelves aſtoniſhing. Nothing but daily experience makes us ſee without amazement, an animal bring forth young, or a tree

bear

bear leaves and fruit. The ſame experience makes it familiar to us, that vegetables are propagated, not only from the ſeed, but from cuttings. So the willow-twig cut off, and only ſtuck in the ground, preſently takes root, and is as perfect a tree as that whence it is taken. This is common in the vegetable kingdom, and we have a rare example of it in the animal.

One ſort of polypus is an aquatic animal, to be found in ditch-water. It is very ſlender, and has on the fore part ſeveral horns, which ſerve it for legs and arms. Between theſe is the mouth; it opens into the ſtomach, which takes up the whole length of the body: indeed the whole body is but one pipe, a ſort of gut which opens at both ends.

The common polypus is about three quarters of an inch long: but there are many ſpecies of them: ſome of which can extend themſelves to the length of ſix or ſeven inches. Even in the ſame ſpecies, the number of legs and arms is not always the ſame: but they have ſeldom fewer than ſix. Both the body and arms may be inflated all manner of ways, and hence it is, that they put themſelves into ſo great a variety of figures.

They do not ſwim, but crawl on the ground, or on any body they meet with in the waters. They uſually fix their poſterior end to ſomething, and ſtretch their bodies and arms into the water. With theſe arms they catch numberleſs inſects, which are ſwimming up and down. A polypus, having ſeized its prey, uſes one or more arms to bring it to his mouth. He can maſter a worm thrice as long as himſelf, which he ſwallows whole: and having drawn all that is nutritive from it, then throws out the ſkin.

" I have cut a polypus in two, between ſeven and eight in the morning, and before three in the afternoon, each part was a complete animal, able to eat a worm as long as itſelf. If a polypus be cut lengthways, beginning at the head, but not quite to the tail, there is a polypus with two heads, two bodies, and one tail. Some of theſe heads and bodies may ſoon be cut lengthways again. Thus I have produced a polypus with ſeven heads, ſeven bodies and one tail. I cut off the heads of this new hydra, ſeven-

others grew up, and each of theſe cut off became a polypus.

" I cut a polypus croſs-ways into two parts; put them together again, and they re-united. I put the poſterior part of one to the anterior of another, they ſoon united into one polypus, which ate the next day, and ſoon put forth young ones from each part.

" As the body of a polypus is but one gut, I have turned it inſide out. The inſide ſoon after became the outſide, and it fed and multiplied as before. They do not copulate at all; but each polypus has the faculty of multiplying itſelf: yea, before it is ſevered from its parent. I have ſeen a polypus while growing out of the ſide of its parent, bring forth young ones; nay, and thoſe young ones themſelves have alſo brought forth others."

Cut a polypus acroſs, and the ſame day the anterior end lengthens itſelf, creeps and eats. The lower part which has no head, gets one, forms itſelf a mouth, and puts forth arms. It is all one, in whatever part the body is cut: cut it into three or four parts, and each becomes a complete polypus.

Cut one lengthways, ſlitting it quite in two, ſo as to form two half pipes. It is not long before the two ſides of them cloſe, they begin at the poſterior part, and cloſe upward, till each half pipe becomes a whole one. All this is done in leſs than an hour, and the polypus produced from each of theſe halves, differs nothing from the firſt, only it has fewer arms. But theſe two are ſoon ſupplied!

But as ſtrange animals as all polypi are, the cluſtering polypi are more ſtrange than the reſt. One ſpecies of theſe are of a bell-like form. Their anterior part, in which is their mouth, is hollowed inward, and reſembles the open end of a bell. Their other extremity ends in a point, to which is fixt a ſtalk or pedicle. The polypus when it is ready to divide, firſt draws in its lips into the cavity: it then by degrees grows round, and preſently after divides itſelf into two other round bodies. Theſe in a few moments open, loſe their ſpherical form, and put on that of a bell, or complete polypus. This is the manner in which cluſtering polypi are multiplied. The whole operation

operation is performed in three quarters of an hour. The cluſter which they form, reſts upon a ſtem, which is fixt to ſome other body at its lower extremity, and from it ariſe other branches: other branches again ſhoot out from theſe in different places; from theſe laſt other, new ones, and ſo on. At the extremity of each branch, is a polypus. The aſſemblage of all theſe branches, with the polypi at their extremities, form a cluſter much reſembling a tuft of flowers. The ſtem which carries all the cluſter, is capable of a remarkable motion, each branch contracts, when it is touched: each can contract itſelf alone, though this ſeldom happens, for in contracting it commonly touches another, which then immediately contracts with it. When the main ſtem which bears the whole cluſter contracts, all the branches contract together, and the whole becomes entirely cloſed. A moment after, the branches and the ſtem again extend themſelves, and the whole cluſter recovers its ordinary figure. A cluſter is formed thus: a ſingle polypus detaching from the cluſter, ſwims about in the water, till it meets with ſome proper body, to fix itſelf upon. It then has a pedicle, but which is no longer than the polypus itſelf; but it becomes eight or nine times as long in four and twenty hours, and is to be the main ſtem of the new cluſter. In a day after it is fixt, it divides itſelf into two, each of which in a few hours divides into two more. Theſe ſoon after put out branches, and all this is reiterated ſeveral times. Thus a principal branch is formed, provided with ſeveral lateral ones, which afterwards become principal ones, with regard to others that ſpring from them.

When a cluſter is nearly ſtript of its polypi, the branches are no longer able to contract. When but a few polypi remain, none can contract but thoſe to which they are fixed. Hence it appears, that this motion in the ſtem and branches of a cluſter, is entirely derived from the polypi. Indeed at firſt ſight one would imagine, that the polypi fixed to the branches of a cluſter, ſpring from them, in the ſame manner as the leaves, the flowers and the fruit of a vegetable ſpring from it. On the contrary the branches compoſing the cluſters of polypi, ſpring from the polypi, which are at their

their extremities, and theſe polypi, which at firſt appear to be fruits, may rather be termed the roots of them.

The nature of corallines, and the mechaniſm of their polypi, (ſays Peyſſonnel) made me conjecture, that it was the ſame with reſpect to ſponges; that animals neſted in the inteſtines of their fibres, and gave them their origin and growth: but I had not yet ſeen the inſects. Sponges appeared to me only as ſkeletons, and I at length diſcovered the worms which form them. They are of four ſpecies. 1. The tube-like ſponge. 2. The cord-like ſponge. 3. The fingered ſponge. 4. They honey-comb ſponge.

Theſe four kinds only differ in form; they have the ſame qualities, and are made by the ſame kinds of worm; they are all compoſed of hard, firm, dirty fibres, ſometimes brittled, ſeparated one from another, having large hollow tubes diſperſed through their ſubſtance: theſe tubes are ſmooth within. Theſe fibres, which conſiſt of the twiſted doubles of the ſponge, form as it were a labyrinth filled with worms, which are eaeaſily cruſhed: but having carefully torn the ſponges, and their groſs fibres, I diſcovered the living worms.

Theſe ſpecies of ſponge commonly grow upon ſandy bottoms. At their origins we perceive a nodule of ſand, or other matter, almoſt petrified, round, which the worms begin to work, and round which they retire, as to their laſt refuge, where I had the pleaſure of ſeeing them play, exerciſe themſelves, and retire, by examining them with the microſcope.

The worms are about one third of a line thick, and two or three lines in length. They are ſo tranſparent that one may diſcern their viſcera through their ſubſtance, and the blood may be ſeen to circulate. They have a ſmall, black head, furniſhed with two pincers; the other extremity is almoſt ſquare, and much larger than the head. Upon the back may be ſeen two white ſtreaks, as if they contained the chyle: theſe two canals are parallel to each other from the head to the other extremity, where they come together. In the middle where the belly and viſcera ought to be placed, a blackiſh matter is perceivable, which has a kind of circulation;

tion ; ſometimes it fills all the body of the worm, ſometimes it gathers towards the head, or at the other end, and ſometimes it follows the motion of the animal. This vermicular motion being at the poſterior extremity, and ends at the head. They have no particular lodge, they walk indifferently into the tubular labyrinth. Theſe ſponges are attached to ſome ſolid body in the ſea. Some kinds are fixed to rocks, others to heaps of ſand, or to pieces of petrified matter: and the ſea putting in motion the ſand, and the little parcels of broken ſhells, forces them into the holes of the ſponge.

So far the Doctor. But ſtill I doubt, whether the worms form the ſponge, or only lodge therein, though I think, the former more probable.

The ſame doubt I have with regard to what follows, "The belemnites is a foſſile, a kind of ſtony ſhell, which has hitherto perplexed the naturaliſts of all countries. Strait ones are common in Sweden, Livonia and Germany, thoſe that are curved are more common in France and England. The nucleus of it ſeems to be a ſtrait concamerated ſhell, which is ſurrounded by a huge ſolid ſubſtance. Now how was this formed? And how is it that ſome have a nuclus, others not? Again, how is it that in ſome, the cavities containing it, are very ſmall, in others not viſible?

In order to underſtand this, we may conſider, that many bodies which we always took for vegetable, are really animal. So the ſeveral coralline ſubſtances, hitherto reputed marine plants, are now generally believed, to be the ſhells of polypi. Is it not then highly probable, that the teſtaceous tribe in general are generated like flies, the latter from a maggot, the former from a polypus? It muſt be ſo with many: and as corals in general ſeem to be conſtructed by polypi, are they not the primary ſtate of all, or moſt of the teſtaceous tribe? If ſo, it is almoſt beyond a conjecture, that the body called a belemnites, (which on being put into acids is found to ferment in like manner as corals) is formed likewiſe by a polypus, from which the nucleus ſeems to be the laſt ſtate. And does not this concamerated body, of which the Belemnites is only the habitation, lead us into the connection and manner

of

of generation, (perhaps particular to the teſtaceous tribe) by remaining within its nidus all its life, whereas the generality quit their nidi as ſoon as they are able to ſhift for themſelves.

The polypus is an animal of the vermicular kind: the bodies of ſome are long and ſlender, like a fine fibre, extremely tender, and from the head proceed a variety of claws or arms, with which it catches its food, and prepares its habitation. They are of various ſhapes and textures; according to the ſpecies of the animal that is to proceed from them, and very wonderful it is, how ſo ſmall an animal ſhould form ſo large a body as the belemnites! Some animals in the terreſtrial parts of the creation, naturally aſſociate together, others ſeek ſolitude. The ſame diſpoſitions we find in the aquatic, then why not among the polypi? Is not this evidently ſeen from the variety of coral bodies? It ſeems in ſome as if thouſands acted in concert togethers; in others each acts for itſelf; of which latter is the belemnites. The ſhape of the belemnites is generally conic, terminating in a point, and of various colours, according to the juices of the ſtratum in which it lay; it has uſually a ſeam running down the whole length of it. Its interior conſtitution ſeems compoſed of ſeveral cruſts, which when broken tranſverſely proceed on rays from the ſeam to the centre. This ſeam I take to have been the habitation of the animal in its polypus ſtate, and in which the body was affixed. The animals of the teſtaceous tribe in general, as they increaſe in age, increaſe their ſhells in thickneſs, until they have lived their ſtated time, and that is done by adding a new cruſt to, as ſeveral, if not all the tubuli, the oyſters, and the nautili, witneſs. By length of time they grow inactive and dead, the effect of extreme old age ſuffering other marine bodies, as worms and oyſters, to affix themſelves to their outer coat. The like appearance we frequently meet with on belemnitæ, when the animal within was either waxed old, or dead.

One might enlarge upon the analogies which may be found, between the origin of theſe minute animals, the origin of plants, and that of thoſe other animals, which

which we are more acquainted with. But we ſhall be better able to judge of thoſe analogies, when we come to know more both of plants and animals.

The ſurpriſing facts which the ſtudy of natural hiſtory lays before us day by day, may convince us, that the nature of plants and animals, is as yet but very imperfectly known: indeed much more imperfectly, than many have been apt to imagine. All we know is very little, in compariſon of what remains unknown. And this conſideration, as it ſhould prompt us, ſtill more diligently to inquire after truth, ſo it ſhould make us exceeding cautious how we judge of the nature of things from ſo few principles as we are at preſent maſters of.

25. One circumſtance more is worthy our obſervation, with regard not only to inſects, but in ſome meaſure to the whole animal creation, namely the various transformations they undergo. Thoſe kinds of animals which are viviparous, which produce their young alive, undergo the ſlighteſt alteration; yet even theſe have ſome. Growth itſelf is the loweſt ſtep of this ladder: and this is common to all animals. Man himſelf, lordly as he is, at his perfect growth, is not only the moſt helpleſs at his birth, but continues ſo longer than any other member of the animal world. However, except that of growth, he undergoes no conſiderable alteration in this life.

Quadrupeds undergo a greater change yearly, by the loſs and renovation of their outward covering. This change however is gradual, and almoſt inſenſible, the latter being of the ſame ſubſtance, and even colour as the former. But there is an exception to this, in thoſe which undergo this change twice in the year, as do the bears, hares and foxes in Greenland, and other extremely cold countries: and the ermins, which are frequent in Yorkſhire, and ſeveral other parts of England, their hair changes white at the approach of winter, and in ſpring reſumes its former colour.

One claſs however of viviparous animals undergo a more ſudden alteration, namely, the ſerpent-kind. Theſe having no hair or fur to loſe gradually, caſt their whole covering at once, and are ſo dexterous therein,

therein, though they have neither feet nor claws, that their whole ſkins are frequently found entire, without even the cornea or outward caſe of the eyes, which accompanies the other exuviæ, being broken.

Next to theſe are oviparous animals. Theſe make their firſt appearance in a ſtate of entire inaction, but being gradually ripened by natural or artificial heat, burſt out, ſome in their complete ſtate, as lizards, ſpiders, and fiſh in general: and others, as birds, requiring like viviparous animals, the addition of the extrementitious parts. Almoſt all the ſpecies of theſe which we know, need the ſame farther change with the viviparous. All birds moult their feathers, and many in cold countries change the colour of them in the winter. Lizards drop their ſkins like ſnakes; one kind of them, water newts, every two or three weeks.

Spiders, crabs, and all whoſe outward covering is cruſtaceous, and therefore incapable of diſtenſion, caſt their ſhells once a year, at which time nature provides them with ſuch ſupplementary juices, by a kind of exudation from their pores, as form a new ſhell beneath.

Proceed we to thoſe animals, whoſe transformations are more complete, which being fully poſſeſt of life in one figure, afterwards aſſume another, or being firſt in one, afterwards inhabit a quite different element.

To give an inſtance of each, the egg of a frog being laid in the water, produces a lively animal which we call a tadpole. He has a thin ſlimy tail, which ſteers him in the water, in which he wholly reſides. But after awhile, legs and feet burſt through the ſkin; the tail drops off, he is a perfect quadruped. He leaps upon the earth, and ranges over that ground, on which ſome time ſince it would have been death to him to be caſt.

The beetle-claſs is an inſtance of the other change and particularly the cock-chaffer. The female depoſites her egg below the ſurface of the earth, which hatches into a grub, with two or three pair of ſtrong forceps, whereby it is enabled to force its way through the mould where it was lodged, and to cut and tear in pieces for its nouriſhment any ſmall roots which come

in

in its way. After ſtaying here two whole years, a ſhelly covering forms over its ſoft body, a pair of fine wings grow on its back, to ſecure which from danger, when not uſed, a pair of ſtrong caſes are provided. And now forcing his way out of the ground, he becomes a lively inhabitant of the air.

CHAP. VI.

General Obſervations and Reflections.

1. AS to the number of animals, the ſpecies of beaſts, including alſo ſerpents, are not very numerous. Such as are certainly known and clearly deſcribed, are not above a hundred and fifty. And yet probably not many that are of any conſiderable bigneſs, have eſcaped the notice of the curious.

The ſpecies of birds, known and deſcribed, are near five hundred, and the ſpecies of fiſhes, ſecluding ſhell-fiſh, as many: but if the ſhell-fiſh are taken in, above ſix times the number. How many of each genus remain undiſcovered, we cannot very nearly conjecture. But we may ſuppoſe, the whole ſum of beaſts and birds to exceed by a third part, and fiſhes by one half, thoſe that are known.

The inſects, taking in the exſanguious, both terreſtrial and aquatic, may for number vie even with plants themſelves. The exſanguious alone by what Dr. Liſter has obſerved and delineated, we may conjecture cannot be leſs (if not many more) than three thouſand ſpecies. Indeed this computation ſeems to be much too low: for if there are a thouſand ſpecies in this iſland and the ſea near it; and if the ſame proportion hold between the inſects native of England, and thoſe of the reſt of the world (about a tenth:) the ſpecies of inſects on the whole globe, will amount to ten thouſand.

Now if the number of creatures even in this lower world,

world, be ſo exceeding great: how great, how immenſe muſt be the power and wiſdom of Him that formed them all! For as it argues far more ſkill in an artificer, to be able to frame both clocks, and watches, and pumps, and many other ſorts of machines, than he could diſplay in making but one of thoſe ſorts of engines: ſo the Almighty declares more of his wiſdom, in forming ſuch a multitude of different ſorts of creatures, and all with admirable and unreproveable art, than if he had created but a few.

2. Again, the ſame ſuperiority of knowledge would be diſplayed, by contriving engines for the ſame purpoſes after different faſhions, as the moving clocks or other engines by ſprings inſtead of weights: and the infinitely wiſe Creator, has ſhewn by many inſtances, that he is not confined to one only inſtrument, for the working one effect, but can perform the ſame thing by divers means. So though moſt flying creatures have feathers, yet hath he enabled ſeveral to fly without them, as the bat, one ſort of lizard, two ſorts of fiſhes, and numberleſs ſorts of inſects. In like manner, although the air-bladder in fiſhes ſeems neceſſary for ſwimming: yet are many ſo formed as to ſwim without it, as firſt, the cartilaginous-kind, which nevertheleſs aſcend and deſcend at pleaſure, although by what means we cannot tell. Secondly, the cetaceous-kind: the air which they receive into their lungs, in ſome meaſure anſwering the ſame end.

Yet again, though God has tempered the blood and bodies of moſt fiſhes to their cold element, yet to ſhew he can preſerve a creature as hot as beaſts themſelves in the coldeſt water, he has placed a variety of theſe cetaceous fiſhes in the northermoſt ſeas. And the copious fat wherewith their bodies are encloſed, by reflecting the internal heat, and keeping off the external cold, keeps them warm even in the neighbourhood of the pole.

Another proof that God can by different means produce the ſame effect, is the various ways of extracting the nutritious juice out of the aliment in various creatures.

In man and beaſts the food firſt chewed, is received into the ſtomach, where it is concocted and reduced into

to

to chyle, and ſo evacuated into the inteſtines, where being mixed with the choler and pancreatic juice, it is farther ſubtilized, and rendered ſo fluid, that its finer parts eaſily enter the mouth of the lacteal veins.

In birds there is no chewing: but in ſuch as are not carnivorous, it is immediately ſwallowed into the crop, or anti-ſtomach (which is obſerved in many, eſpecially piſcivorous birds (where it is moiſtened by ſome proper juice, and then transferred to the gizzard, by the working of whoſe muſcles, aſſiſted by ſmall pebbles which they ſwallow for that purpoſe, it is ground ſmall, and ſo tranſmitted to the inteſtines.

In oviparous reptiles, and all kind of ſerpents, there is neither chewing nor comminution in the ſtomach, but as they ſwallow animals whole, ſo they void the ſkins unbroken, having extracted the nutritious juices. Here, by the bye, we may obſerve the wonderful dilatability of the throats and gullets of ſerpents. Two entire adult mice have been taken out of the ſtomach of an adder, whoſe neck was no bigger than one's little finger.

Fiſhes, which neither chew, nor grind their meat, do, by means of a corroſive juice in their ſtomach, rereduce ſkin, bones, and all into chyle. And yet this juice ſhows no acidity to the taſte. But how mild ſoever it taſtes, it corrodes all animal ſubſtances, as aqua fortis does iron.

3. Several eminent men have been of opinion, that all brutes are mere machines. This may be agreeable enough to the pride of man; but it is not agreeable to daily obſervation. Do we not continually obſerve in the brutes which are round about us, a degree of reaſon? Many of their actions cannot be accounted for without it: as that commonly noted of dogs, that runniug before their maſters, they will ſtop at the parting of the road, till they ſee which way their maſters take. And when they have gotten what they fear will be taken from them, they run away and hide it. Nay, what account can be given, why a dog being to leap on a table, which he ſees he cannot reach at once, if a ſtool or chair ſtands near it, firſt mounts that, and thence proceeds to the table? If he were mere clock-

work,

work, and his motion cauſed by a material ſpring: that ſpring being once ſet to work, would carry the machine in a right line, towards the object that put it in motion.

Were it true, that brutes were mere machines, they could have no perception of pleaſure or pain. But how contrary is this, to the doleful ſignifications they give, when beaten or tormented? How contrary to the common ſenſe of mankind? For do we not all naturally pity them, apprehending them to feel pain juſt as we do? Whereas no man is troubled to ſee a plant torn, or cut, or mangled how you pleaſe. And how contrary to ſcripture? "A righteous man regardeth the life of his beaſt: but the tender mercies of the wicked are cruel," Prov. xi. 10. The former clauſe is uſually rendered, "a good man is merciful to his beaſt." And this is the true rendering, as appears by the oppoſite clauſe, that the wicked is cruel. Cruelty then may be exerciſed toward beaſts. But this could not be, were they mere machines.

4. The natural inſtinct of all creatures, and the ſpecial proviſion made for ſome of the moſt helpleſs, do in a particular manner demonſtrate the Creator's care.

Firſt, what an admirable principle is the natural affection of all creatures toward their young! By means of this, with what care do they nurſe them up, thinking no pains too great to be taken for them, no danger too great to be ventured upon, for their guard and ſecurity! How will they careſs them with their affectionate notes, put food into their mouths, ſuckle them, cheriſh and keep them warm, teach them to pick and eat, and gather food for themſelves: and in a word, perform the whole part of ſo many nurſes, deputed by the ſovereign Lord of the world, to help ſuch young and ſhiftleſs creatures till they are able to ſhift for themſelves.

Other animals, inſects in particular, whoſe off-ſpring is too numerous for the parent's proviſion, are ſo generated, as to need none of their care. For they arrive immediately at their perfect ſtate, and ſo are able to ſhift for themſelves. Yet thus far the parental inſtinct, (equal to the moſt rational fore-ſight) extends, that they

they do not drop their eggs any where, but in commodious places, ſuitable to their ſpecies. And ſome include in their neſts, ſufficient and agreeable food, to ſerve their young till they come to maturity.

And for the young themſelves. As the parent is not able to carry them about, to clothe them and dandle them, as man doth; how admirably is it contrived, that they can ſoon walk about, and begin to ſhift for themſelves! How naturally, do they hunt for their teat, ſuck, pick and take in their proper food!

On the other hand, the young of man, (as their parent's reaſon is ſufficient, to help, to nurſe, feed and clothe them) are born utterly helpleſs, and are more abſolutely than any creature, caſt upon their parents' care.

Secondly, what admirable proviſion is made for ſome of the moſt helpleſs creatures, at a time when they muſt otherwiſe utterly periſh! The winter is an improper ſeaſon to afford food to inſects and many other animals. When the fields, trees, and plants are naked, and the air is chilled with froſt; what would become of ſuch animals, whoſe tender bodies are impatient of cold, and who are nouriſhed only by the produce of the ſpring or ſummer? To prevent their total deſtruction, the Wiſe Preſerver of the world has ſo ordered, that in the firſt place, thoſe which are impatient of cold, ſhould have ſuch a peculiar ſtructure of body, as during that ſeaſon, not to ſuffer any waſte, nor conſequently need any recruit. Hence many ſorts of birds, and almoſt all inſects, paſs the whole winter without any food. And moſt of them without any reſpiration. It ſeems all motion of the animal juices is extinct. For though cut in pieces they do not awake, nor does any fluid ooze out at the wound. This ſleep therefore is little leſs than death, and their waking, than a reſurrection: when the returning ſun revives them and their food together.

The next proviſion is for ſuch creatures as can bear the cold, but would want food. This is provided again in ſome, by a long patience of hunger; in others by their wonderful inſtinct, in laying up food before hand, againſt the approaching winter. By ſome of

theſe,

theſe, their little treaſuries are at the proper ſeaſon well ſtocked with proviſions. Yea, whole fields are here and there beſpread with the fruits of the neighbouring trees laid carefully up in the earth, and covered ſafe by provident little animals.

5. And what a prodigious act is it of the Creator's indulgence to the poor, ſhiftleſs irrationals, that they are already furniſhed with ſuch clothing, as is proper to their place and buſineſs! With hair, with feathers, with ſhells, or with firm armature, all nicely accommodated, as well to the element wherein they live, as to their ſeveral occaſions there. To beaſts, hair is a commodious clothing: which together with the apt texture of their ſkin, fit them in all weathers to lie on the ground, and to do their ſervice to man. The thick and warm fleeces of others, are a good defence againſt the cold and wet, and alſo a ſoft bed: yea, and to many a comfortable covering for their tender young.

All the animals near Hudſon's-Bay, are clothed with a cloſe, ſoft, warm fur. But what is ſtill more ſurpriſing, and what draws all attentive minds to admire the wiſdom and goodneſs of Providence, is, that the very dogs and cats which are brought thither from England, on the approach of winter change their appearance, and acquire a much longer, ſofter, and thicker coat of hair than they originally had.

And as hair is a commodious dreſs for beaſts, ſo are feathers for birds. They are not only a good guard againſt wet and cold, but nicely placed every where on the body, to give them an eaſy paſſage through the air, and to waft them through that thin medium. How curious is their texture for lightneſs, and withal cloſe and firm for ſtrength! And where it is neceſſary they ſhould be filled, what a light, medullary ſubſtance are the filled with? So that even the ſtrongeſt parts, far from being a load to the body, rather help to make it light and buoyant. And how curiouſly are the vanes of the feathers wrought, with capillary filaments, nearly interwoven together, whereby they are ſufficiently cloſe and ſtrong, both to guard the body againſt the injuries of the weather, and to impower the wings,

wings, like ſo many ſails, to make ſtrong impulſes on the air in their flight.

No leſs curious is the clothing of reptiles. How well adapted are the rings of ſome, and the contortions of the ſkin of others, not only to fence the body ſufficiently, but enable them to creep, to perforate the earth, and to perform all the offices of their ſtate, better than any other covering?

Obſerve, for inſtance, the tegument of the earth-worms, made in the completeſt manner, for making their paſſage through the earth, wherever their occaſions lead them. Their body is made throughout of ſmall rings, which have a curious apparatus of muſcles, that enable them with great ſtrength to dilate, extend, or contract their whole body. Each ring is likewiſe armed with ſtiff, ſharp prickles, which they can open at pleaſure, or ſhut cloſe to their body. Laſtly, under their ſkin there is a ſlimy juice, which they emit as occaſion requires, to lubricate the body, and facilitate their paſſage into the earth. By all theſe means they are enabled, whith eaſe and ſpeed, to work themſelves into the earth, which they could not do, were they covered with hair, feathers, ſcales, or ſuch clothing like any of the other creatures.

How wiſely likewiſe are the inhabitants of the waters clothed! The ſhells of ſome fiſhes, are a ſtrong guard to their tender bodies, and conſiſtent enough with their ſlow motion: while the ſcales and fins of others afford them an eaſy and ſwift paſſage through the waters.

6. Admirable likewiſe is the ſagacity of brute-animals in the conveniency and method of their habitations. Their architectonic ſkill herein, exceeds all the ſkill of man. With what inimitable art do ſome of theſe poor, untaught creatures, lay a parcel of rude ugly ſticks or ſtraws together! with what curioſity do they line them within, yea, wind and place every hair, feather, or lock of wool, to guard and keep warm the tender bodies, both of themſelves and their young? And with what art do they thatch over and coat their neſts without, to deceive the eye of the ſpectators, as well as to guard and fence them againſt the injuries of the weather?

Even

Even inſects, thoſe little, weak, tender creatures, what artiſts are they in building their habitations? How does the bee gather its comb from various flowers, the waſp from ſolid timber? With what accuracy do other inſects perforate the earth, wood, yea, ſtone itſelf? Farther yet, with what care and neatneſs do moſt of them line their houſes within, and ſeal them up and fence them without? How artificially do others fold up the leaves of trees; others glue light bodies together, and make floating houſes, to tranſport themſelves, to and fro, as their various occaſions require!

7. Another inſtance of the wiſdom of Him that made and governs the world, we have in the balance of creatures. The whole ſurface of the terraqueous globe, can afford room and ſupport, to no more than a determinate number of all ſorts of creatures. And if they ſhould increaſe to double or treble the number, they muſt ſtarve or devour one another. To keep the balance even, the great author of nature has determined the life of all creatures to ſuch a length, and their increaſe to ſuch a number, proportioned to their uſe in the world. The life indeed of ſome hurtful creatures is long; of the lion in particular. But then their increaſe is exceeding ſmall: and by that means they do not overſtock the world. On the other hand, where the increaſe is great, the lives of thoſe creatures are generally ſhort. And beſide this, they are of great uſe to man, either for food or on other occaſions. This indeed ſhould be particularly obſerved, as a ſignal inſtance of divine providence, that uſeful creatures are produced in great plenty: others in ſmaller numbers. The prodigious increaſe of inſects, both in and out of the waters may exemplify the former obſervation. For innumerable creatures feed upon them, and would periſh, were it not for this ſupply. And the latter is confirmed by what many have remarked: that creatures of little uſe, or by their voraciouſneſs, pernicious, either ſeldom bring forth, or have but one or two at a birth.

8. How remarkable is the deſtruction and reparation of the whole animal creation? The ſurface of the earth

earth is the inexhauſtible ſource whence both man and beaſt derive their ſubſiſtence. Whatever lives, lives on what vegetates, and vegetables in their turn, live, on whatever has lived or vegetated: it is impoſſible for any thing to live, without deſtroying ſomething elſe. It is thus only that animals can ſubſiſt themſelves, and propagate their ſpecies.

God, in creating the firſt individual of each ſpecies, animal or vegetable, not only gave a form to the duſt of the earth, but a principle of life, incloſing in each, a greater or ſmaller quantity of original particles, indeſtructible and common to all organized beings. Theſe paſs from body to body, ſupporting the life, and miniſtering to the nutrition and growth of each. And when any body is reduced to aſhes, theſe original particles, on which death hath no power, ſurvive and paſs into other beings, bringing with them nouriſhment and life. Thus every production, every renovation, every increaſe by generation or nutrition, ſuppoſes a preceding deſtruction, a converſion of ſubſtance, an acceſſion of theſe organical particles, which ever ſubſiſting in an equal number, render nature always equally full of life.

The total quantity of life in the univerſe is therefore perpetually the ſame. And whatever death ſeems to deſtroy, it deſtroys no part of that primitive life, which is diffuſed through all organized beings. Inſtead of injuring nature, it only cauſes it to ſhine with the greater luſtre. If death is permitted to cut down individuals, it is only, in order to make of the univerſe, by the reproduction of beings, a theatre ever crowded, a ſpectacle ever new. But it is never permitted to deſtroy the moſt inconſiderable ſpecies.

That beings may ſucceed each other, it is neceſſary that there be a deſtruction among them. Yet like a provident mother, nature in the midſt of her inexhauſtible abundance, has prevented any waſte, by the few ſpecies of carnivorous animals, and the few individuals of each ſpecies; multiplying at the ſame time both the ſpecies and individuals of thoſe that feed on herbage. In vegetables ſhe ſeems to be profuſe, both with regard to the number and fertility of the ſpecies.

In the ſea indeed all the ſpecies are carnivorous.

But though they are perpetually preying upon, they never deſtroy each other, becauſe their fruitfulneſs is equal to their depredations.

" Thus through ſucceſſive ages ſtands
Firm fixt thy providential care!
Pleas'd with the works of thine own hands
Thou doſt the waſtes of time repair."

9. I add a few more reflections on the world in general. The ſame wiſe Being, who was pleaſed to make man, prepared for him alſo an habitation ſo advantageouſly placed, that the heavens and the reſt of the univerſe might ſerve it both as an ornament and a covering. He conſtructed likewiſe the air which man was to breathe, and the fire which was to ſuſtain his life. He prepared alſo metals, ſalts, and all terreſtrial elements to renew, and maintain throughout all ages, whatever might be on any account neceſſary for the inhabitants of the earth.

The ſame Divine Ruler is manifeſt in all the objects that compoſe the univerſe. It is he that cauſed the dry land to appear, above the ſurface of the ocean, that guaged the capacity of that amazing reſervoir, and proportioned it to the fluid it contains. He collects the riſing vapours, and cauſes them to diſtil in gentle ſhowers. At his command the ſun darts his enlivening rays, and the wind ſcatters the noxious effluvia, which if they were collected together might deſtroy the human race.

He formed thoſe hills and lofty mountains which receive and retain the water within their bowels, in order to diſtribute it with œconomy to the inhabitants of the plains, and to give it ſuch an impulſe, as might enable it to overcome the unevenneſs of the lands, and convey it to the remoteſt habitations.

He ſpread under the plains, beds of clay, or compact earths, there to ſtop the waters, which after a great rain. make their way through innumerable little paſſages. Theſe ſheets of water frequently remain in a level with the neighbouring rivers, and fill our wells with their redundancy, or as thoſe ſubſide, flow into them again.

He

He proportioned the variety of plants in each country, to the exigencies of the inhabitants, and adapted the variety of the ſoils, to the nature of thoſe plants.

He endued numerous animals with mild diſpoſitions, to make them the domeſtics of man: and taught the other animals to govern themſelves, with an averſion to dependence, in order to continue their ſpecies without loading man with too many cares.

If we more nearly ſurvey the animal and vegetable world, we find all animals and plants have a certain and determined form, which is invariably the ſame. So that if a monſter ever appear, it cannot propagate its kind, and introduce a new ſpecies into the univerſe. Great indeed is the variety of organized bodies. But their number is limited. Nor is it poſſible to add a a new genus either of plants or animals, to thoſe of which God has created the germina, and determined the form.

The ſame Almighty power has created a preciſe number of ſimple elements, eſſentially different from each other, and invariably the ſame. By theſe he varies the ſcene of the univerſe, and at the ſame time prevents its deſtruction, by the very immutability of the nature and number of theſe elements. So that the whole is for ever changed, and yet eternally the ſame.

Yet if we would account for the origin of theſe elements, we are involved in endleſs uncertainty. We can only ſay, he who has appointed their different uſes in all ages, has rendered thoſe uſes infallible, by the impoſſibility of either deſtroying or increaſing them.

Herein we read the characters of his power, which is invariably obeyed; of his wiſdom, which has abundantly provided for every thing; and of his tender kindneſs toward man, for whom he has provided ſervices equally various and infallible. It is an additional proof of his continual care of his creatures, that though every thing be compoſed of ſimple elements, all placed within our reach, yet no power is able to deſtroy the leaſt particle of them. Nothing but the ſame cauſe which was able to give them birth, can annihilate them, or change their nature. In truth, the deſign and will of the Creator, is the only phyſical cauſe of

the general œconomy of the world: the only phyſical cauſe of every organized body, every germin that flouriſhes in it; the only phyſical cauſe of every minute, elementary particle, which enters into the compoſition of all.

We muſt not then expect ever to have a clear and full conception of effects, natures, and cauſes. For where is the thing which we can fully conceive? We can no more comprehend either what body in general is, or any particular body, ſuppoſe a maſs of clay, or a ball of lead, than what a ſpirit, or what God is.

If we turn our eyes to the minuteſt parts of animal life, we ſhall be loſt in aſtoniſhment! And though every thing is alike eaſy to the Almighty, yet to us it is matter of the higheſt wonder, that in thoſe ſpecks of life, we find a greater number of members to be put in motion, more wheels and pullies to be kept going, and a greater variety of machinery, more elegance and workmanſhip (ſo to ſpeak) in the compoſition, more beauty and ornament in the finiſhing, that are ſeen in the enormous bulk of the crocodile, the elephant, or the whale. Yea, they ſeem to be the effects of an art, as much more exquiſite as the movements of a watch are, than thoſe of a coach or waggon.

Hence we learn, that an atom, to God, is as a world: and a world but as an atom: juſt as to him, one day is as a thouſand years; and a thouſand years but as one day. Every ſpecies likewiſe of theſe animalcula may ſerve to correct our pride, and ſhew how inadequate our notions are, to the real nature of things. How extremely little can we poſſibly know, either of the largeſt or ſmalleſt part of the creation? We are furniſhed with organs capable of diſcerning, to a certain degree, of great or little only. All beyond is as far beyond the reach of our conceptions, as if it had never exiſted.

Proofs of a wiſe, a good and powerful Being are indeed deducible from every thing around us: but the extremely great, and the extremely ſmall, ſeem to furniſh us with thoſe that are moſt convincing. And perhaps, if duly conſidered, the fabric of a world, and the fabric of a mite, may be found equally ſtriking and concluſive.

Glaſſes

Glaſſes diſcover to us numberleſs kinds of living creatures, quite indiſcernible to the naked eye. And how many thouſand kinds may there be, gradually decreaſing in ſize, which we cannot ſee by any help whatever? Yet to all theſe we muſt believe God has not only appointed the moſt wiſe means for preſervation and propagation, but has adorned them with beauty equal at leaſt to any thing our eyes have ſeen.

In ſhort, the world around us is the mighty volume wherein God hath declared himſelf. Human languages and characters are different in different nations. And thoſe of one nation are not underſtood by the reſt. But the book of nature is written in an univerſal character, which every man may read in his own language. It conſiſts not of words, but things, which picture out the Divine perfections. The firmanent every where expanded, with all its ſtarry hoſt, declares the immenſity and magnificence, the power and wiſdom of its Creator. Thunder, lightning, ſtorms, earthquakes and volcanos, ſhew the terror of his wrath. Seaſonable rains, ſun-ſhine and harveſt, denote his bounty and goodneſs, and demonſtrate how he opens his hand, and fills all living things with plenteouſneſs. The conſtantly ſucceeding generations of plants and animals, imply the eternity of their firſt cauſe. Life ſubſiſting in millions of different forms, ſhews the vaſt diffuſion of this animating power, and death the infinite diſproportion between him and every little thing.

Even the actions of animals are an eloquent and a pathetic language. Thoſe that want the help of man have a thouſand engaging ways, which, like the voice of God ſpeaking to his heart, command him to preſerve and cheriſh them. In the mean time the motions or looks of thoſe which might do him harm, ſtrike him with terror, and warn him, either to fly from or arm himſelf againſt them. Thus it is, that every part of nature directs us to nature's God.

10. The reader will eaſily excuſe my concluding this chapter alſo, with an extract from Mr. Hervey.

In all the animal world, we find no tribe, no individual neglected by its Creator. Even the ignoble creatures

creatures are moſt wiſely circumſtanced and moſt libe" rally accommodated.

They all generate in that particular ſeaſon, which ſupplies them with a ſtock of proviſions, ſufficient not only for themſelves, but for their increaſing families. The ſheep yean, when there is herbage to fill their udders, and create milk for their lambs. The birds hatch their young, when new-born inſects ſwarms on every ſide. So that the caterer, whether it be male or female parent, needs only to alight on the ground, or make a little excurſion into the air, and find a feaſt ready dreſſed for the mouths at home.

Their love to their offspring, while they are helpleſs, is invincibly ſtrong: whereas the moment they are able to ſhift for themſelves, it vaniſhes as though it had never been. The hen that marches at the head of her little brood, would fly at a maſtiff in their defence. Yet within a few weeks, ſhe leaves them to the wide world, and does not even know them any more.

If the God of Iſrael inſpired Bezaleel and Aholiah "with wiſdom and knowledge in all manner of workmanſhip," the God of nature has not been wanting, in his inſtructions to the fowls of the air. The ſkill with which they erect their houſes, and adjuſt their apartments is inimitable. The caution with which they hide their abodes from the ſearching eye, or intruding hand, is admirable. No general, though fruitful in expedients, could build ſo commodious a lodgment. Give the moſt celebrated artificer the ſame materials, which theſe weak and inexperienced creatures uſe. Let a Jones or a Demoivre have only ſome rude ſtones or ugly ſticks, a few bits of dirt or ſcraps of hair, a lock of wool, or a coarſe ſprig of moſs, and what works could they produce?

We extol the commander, who knows how to take advantage of the ground; who by every circumſtance embarraſſes the forces of his enemy, and advances the ſucceſs of his own. Does not this praiſe belong to the feathered leaders? Who fix their penſile camp, on the dangerous branches that wave aloft in the air, or dance over the ſtream. By this means the vernal gales rock their cradle, and the murmuring waters lull the young, while both concur to terrify their enemies,

and

and keep them at a diſtance. Some hide their little houſhold from view, amidſt the ſhelter of entangled furze. Others remove it from diſcovery, in the centre of a thorny thicket. And by one ſtratagem or another they are generally as ſecure, as if they intrenched themſelves in the earth.

If the ſwan has large ſweeping wings, and a copious ſtock of feathers, to ſpread over his callow young, the wren makes up by contrivance what is wanting in her bulk. Small as ſhe is, ſhe will, be obliged to nurſe up, a very numerous iſſue. Therefore with ſurpriſing judgment ſhe deſigns, and with wonderful diligence finiſhes her neſt. It is a neat oval, bottomed and vaulted over with a regular concave: within made ſoft with down, without thatched with moſs, only a ſmall aperture left for her entrance. By this means the enlivening heat of her body is greatly increaſed during the time of incubation. And her young no ſooner burſt the ſhell, than they find themſelves ſcreened from the annoyance of the weather, and comfortably repoſed, till they gather ſtrength in the warmth of a bagnio.

Perhaps we have been accuſtomed to look upon inſects, as ſo many rude ſcraps of creation. But if we examine them with attention, they will appear ſome of the moſt poliſhed pieces of divine workmanſhip. Many of them are decked with the richeſt finery. Their eyes are an aſſemblage of microſcopes: the common fly, for inſtance, who ſurrounded with enemies, has neither ſtrength to reſiſt, nor a place of retreat to ſecure herſelf. For this reaſon ſhe has need to be very vigilant, and always upon her guard. But her head is ſo fixed that it cannot turn to ſee what paſſes, either behind or around her. Providence has therefore given her, not barely a retinue, but more than a legion of eyes. Inſomuch that a ſingle fly is ſuppoſed to be the miſtreſs of no leſs than eight thouſand. By the help of this truly amazing apparatus, ſhe ſees on every ſide, with the utmoſt eaſe and ſpeed, though without any motion of the eye, or flexion of the neck.

The dreſs of inſects is a veſture of reſplendent colours, ſet with an arrangement of the brighteſt gems. Their wings are the fineſt expanſion imaginable, compared to which, lawn is as coarſe as ſackcloth. The caſes

which

which encloſe their wings, glitter with the fineſt varniſh, are ſcooped into ornamental flutings, are ſtudded with radiant ſpots, or pinked with elegant holes. Not one but is endued with weapons to ſeize their prey, and dexterity to eſcape their foe, to diſpatch the buſineſs of their ſtation, and enjoy the pleaſure of their condition.

What if the elephant is diſtinguiſhed by his huge proboſcis? The uſe of this is anſwered in theſe his meaner relations, by the curious feelers, remarkable, if not for their enormous ſize, yet for their ready flexion and quick ſenſibility. By theſe they explore their way in the darkeſt road: by theſe they diſcover and avoid, whatever might defile their neat apparel, or endanger their tender lives.

Every one admires the majeſtic horſe. With how rapid career does he bound along the plain? Yet the graſs-hopper ſprings forward with a bound abundantly more impetuous. The ant too, in proportion to its ſize, excels him both in ſwiftneſs and ſtrength: and will climb precipices, which the moſt courageous courſer dares not attempt to ſcale. If the ſnail moves more ſlowly, ſhe has however no need to go the ſame way twice over: becauſe whenever ſhe departs, whereever ſhe removes, ſhe is always at home.

The eagle it is true, is privileged with pinions that out-ſtrip the wind. Yet neither is that poor outcaſt, the groveling mole, diſregarded by divine providence. Becauſe ſhe is to dig her cell in the earth, her paws ſerve for a pick-axe and ſpade. Her eye is ſunk deep into its ſocket, that it may not be hurt by her rugged ſituation. And as it needs very little light, ſhe has no reaſon to complain of her dark abode. So that her ſubterranean habitation, which ſome might call a dungeon, yields her all the ſafety of a fortified caſtle, and all the delights of a decorated grot.

Even the ſpider, though abhorred by man, is the care of all-ſuſtaining heaven. She is to ſupport herſelf by trepanning the wandering fly. Suitable to her employ, ſhe has bags of glutinous moiſture. From this ſhe ſpins a clammy thread, and weaves it into a tenacious net. This ſhe ſpreads in the moſt opportune place. But knowing her appearance would deter him

from

from approaching, ſhe then retires out of ſight. Yet ſhe conſtantly keeps within diſtance; ſo as to receive immediate intelligence when any thing falls into her toils, ready to ſpring out in the very inſtant. And it is obſervable, when winter chills the air, and no more inſects rove through it, knowing her labour would be in vain, ſhe leaves her ſtand, and diſcontinues her work.

I muſt not forget the inhabitants of the hive. The bees ſubſiſt as a regular community. And their indulgent Creator has given them all implements neceſſary either for building their combs, or compoſing their honey. They have each a portable veſſel, in which they bring home their collected ſweets: and they have the moſt commodious ſtore-houſes, wherein they depoſit them. They readily diſtinguiſh every plant, which affords materials for their buſineſs; and are complete practitioners in the arts of ſeparation and refinement. They are aware that the vernal bloom and ſummer ſun continue but for a ſeaſon. Therefore they improve to the utmoſt every ſhining hour, and lay up a ſtock ſufficient to ſupply the whole ſtate, till their flowery harveſt returns.

If the maſter of this lower creation is ennobled with the powers of reaſon, the meaneſt claſſes of ſenſitive beings, are endued with the faculty of inſtinct: ſagacity which is neither derived from obſervation, nor waits the finiſhing of experience: which without a tutor teaches them all neceſſary ſkill, and enables them without a pattern to perform every needful operation. And what is more remarkable, it never miſleads them, either into erroneous principles, or pernicious practices: nor ever fails them in the moſt nice and difficult of their undertakings.

Let us ſtep into another element, and juſt viſit the watry world. There is not one among the innumerable myriads, that ſwim the boundleſs ocean, but is watched over by the Sovereign eye, and is ſupported by his Almighty hand. He has condeſcended even to beautify them. He has given the moſt exact proportion to their ſhape, the gayeſt colours to their ſkin, and a poliſhed ſurface to their ſcales. The eyes of ſome are ſurrounded with a ſcarlet circle: the back of

others diverſified with crimſon ſtains. View them when they glance along the ſtream, or when they are freſh from their native brine, the ſilver is not more bright, nor the rainbow more glowing than their vivid, gloſſy hues.

But as they have neither hands nor feet, how can they help themſelves or eſcape their enemies? By the beneficial, as well as ornamental furniture of fins. Theſe when expanded, like maſts above, and ballaſt below, poiſe their floating bodies, and keep them ſteadily upright. They are likewiſe greatly aſſiſted by the flexibility and vigorous activity of their tails: with which they ſhoot through the paths of the ſea, ſwifter than a veſſel with all its ſails. But we are loſt in wonder at the exquiſite contrivance and delicate formation of their gills: by which they are accommodated, even in that denſe medium, with the benefits of reſpiration! A piece of mechaniſm this, indulged to the meaneſt of the fry: yet infinitely ſurpaſſing, in the fineneſs of its ſtructure and operation, whatever is curious in the works of art, or commodious in the palaces of princes.

PART THE THIRD.

Of PLANTS and FOSSILS.

CHAP. I.

Of PLANTS.

1. *What we mean by Plants.*
2. *Their liquid Parts.*
3. *Their ſolid Parts.*
4. *Of the Bark.*
5. *The Wood.*
6. *The Pith.*

7. *The*

7. *The Root and Branches.*
8. *The Leaves.*
9. *The Nutrition of Plants.*
10. *Water not the Nutriment of Plants.*
11. *The Motion of the Nutritive Juice.*
12. *The Deſcent and Aſcent of the Sap.*
13. *Of the Increaſe of Grain and Seeds.*
14. *Of Male and Female Plants.*
15. *Of the Sleep of Plants.*
16. *Of the Agreement between Plants and Animals.*
17. *Of the Generation of Plants.*
18. *Of their Flowers.*
19. *Their Seeds.*
20. *Their Fruits.*
21. *Of the Perſpiration of Plants.*
22. *Trees inverted will grow.*
23. *Of the Propagation of ſeveral Plants.*
24. *Of Grain planted in various Subſtances.*

1. BY plants we mean organized bodies, deſtitute of ſenſe and motion, fixed in the earth, and drawing their nouriſhment from it by their roots. Touching theſe, we may conſider, firſt the ſtructure of their parts, and then their nutrition and generation.

2. The parts of which they are compoſed are either liquid or ſolid. The liquid are uſually divided into juices and tears. The juice is to the plant, what blood is to an animal, and is various in the various kinds of plants. Tears are liquors which are emitted from them, whether they ſweat out of them naturally: or are drawn out of them, either by art, or by the heat of the ſun. Some of theſe remain liquid; others grow by degrees into a firm conſiſtence.

3. Plants conſiſt of three diſſimilar, ſolid parts, the root, the trunk, and the branches. In each of theſe we may obſerve three ſimilar parts, the bark, the wood, and the pith.

4. To begin with the trunk. Here we may firſt obſerve the bark; whoſe ſurface conſiſts of little bladders, which ſurround the trunk like a ring. Theſe, which

which are commonly filled with ſome kind of juice, being removed, there occur various ranks of woody fibres, curiouſly wrought in a kind of net-work, one row above another. The intervals alſo between thoſe fibres, are all filled with little veſſels. The uſe of the bark ſeems to be, not only like ſkin, to cover the wood and pith, but alſo to concoct the nutritive juice, and forward the growth of the plant, it is probable the juice aſcends from the root, through the fibres, and is ſuſtained by the unevenneſs therein, till it is lodged in the veſſels. In theſe the new juice being mixed, with that they contained before, is fermented and rarified to ſuch a degree, as is needful for its nouriſhment.

It has been a common opinion, that trees only live by the aſcent of the ſap in the bark, or between the bark and the wood. But this evidently appears to be a vulgar error, from the inſtance of a large, old elm, in Magdalen College Grove at Oxford, which was quite diſbarked all round, at moſt places two feet, at ſome four feet from the ground. Notwithſtanding this, it grew and flouriſhed many years, as well as any tree in the grove. What is more, it was likewiſe, without all pith, being hollow within as a drum. Add to this, that the plane and cork-trees, diveſt themſelves every year of all their old bark, (as ſnakes do of their ſkins) and acquire a new one. Now during the change from one to the other, it is clear they are not nouriſhed by the bark. Therefore there muſt be other veſſels, beſides thoſe of the bark, capable of conveying the ſap. It is probable, the bark may ordinarily do this; but that when the ordinary conveyance fails, ſome of the woody parts, (which were all ſap-veſſels once) reſume their ancient office: ſo far, at leaſt, as to keep the tree alive, though not to increaſe its bulk. Perhaps this is the uſe of the ſap-veſſels in the wood different from that of thoſe in the bark. Theſe are deſigned for the continuation of the tree; thoſe in the bark for its augmentation.

It ſeems the bark in fruit-trees is principally deſigned for the augmentation of the tree itſelf, while the finer veſſels of the woody part, ſtrain and prepare the juices for the fruit. A gentleman near Cork, obſerving that his peach-tree grew exceedingly, but bore no fruit, cut

off

off the bark almoſt quite round, for the breadth of two fingers. The next year the tree hardly grew at all, but bore abundance of fruit.

Again. As animals are furniſhed with the cellular membrane, which inveſts and covers all the fleſhy parts, and ſcreens them from external cold; ſo plants are encompaſſed with a bark, replete with fleſhy juices, by means whereof even the winter cold is kept off, and hindered from freezing the juices in the veſſels. And thoſe ſorts of trees, whoſe bark abounds with oil, remain green all the year round.

5. In the wood likewiſe there are obſerved concave fibres, woven as it were of various veſicles, and ſtretching all the length of the wood, as do the fibres of the bark. Theſe have intervals between them, in which are tranſverſe veſicles, reaching to the very pith. There are other fibres, which run obliquely, and are far larger, but not ſo numerous as the former. In ſome trees there are alſo ſeveral rows of tubes, which emit a thick milky liquor.

6. The pith is the middle of the wood. It conſiſts of various rows of hollow globules, covered with a fine membrane. In ſome trees it contains a peculiar juice, which ſometimes hardens, or grows black. In tender ſhoots the pith (which is frequently hexagonal) is not exactly in the middle: but is nearer the bark on the ſouth-ſide, than on the north-ſide of the plant. It is a conſtant obſervation, that the pith leſſens as the tree grows. Some have imagined it to be the heart of the plant: but this cannot be. For ſome trees will flouriſh and bear fruit after the pith is taken out. Beſides this, there is in ſome trees a blea, a white and a tender ſubſtance, between the bark and the wood.

7. The root has nearly the ſame veſſels as the trunk. Through it the juice paſſes that nouriſhes the plant. The roots of ſome plants are full of hollow threads, which tranſmit nouriſhment to the upper parts. This in other plants inſinuates itſelf through the pores that are in the bark of the root. The branches of a plant

agree

agree with the trunk, in all the eſſential parts of its ſtruuctre.

If no moiſture comes to the roots of trees they cannot grow; but if it comes only to the points of the root, though all the reſt remain dry, they grow well. For the root ſhoots out yearly a ſharp pointed tender part, ſomewhat like the ſharp bud on the end of a ſprig, by which it not only enlarges itſelf in breadth, as the branches do above, but alſo receives its nouriſhment. And that tender part moves toward the ſoft and moiſt earth. So that to looſen the earth at the points of the roots, much helps the growth of all plants.

8. On the ſmalleſt part of the branches grow the leaves; of theſe we may obſerve, 1. The fibres of the leaf ſtand not on the ſtalk in an even line, but always in an angular or circular poſture; and their vaſcular fibres or threads, are three, five or ſeven. The reaſon of this poſition is, for the more erect growth, and for the greater ſtrength of the leaf: as alſo for the ſecurity of its ſap. 2. The accurate poſition of theſe fibres, which often take in the eighth part of a circle, as in mallows; in ſome plants a tenth; but in moſt a twelfth. 3. The art in folding up the leaves before the eruption, is incomparable both for elegance and ſecurity. They take up the leaſt room their form will bear; and are ſo conveniently couched, as to be capable of receiving protection from other parts, and of giving it to each other.

Leaves conſiſt of fibres continued from the trunk of the tree. They are clothed with an extremely thin pellicle which is covered with the fineſt down. Their ſkin or coat is only that of the branches extended, as gold is by beating. In the bud they are folded up, almoſt in the manner of a fan, ſometimes in two, ſometimes in ſeveral plaits. But if they are too thick to plait commodiouſly in two, and to be ranged againſt each other, or if they are too ſmall a number, or their fibres too delicate: inſtead of being plaited, they are rolled up, and form either a ſingle roll, or two rolls, which begin at each extremity of the leaf, and meet in the middle. There are alſo ſome plants, as fern in particular, which form three rolls.

The

The chief uſe of leaves ſeems to be, 1. To catch the dew and rain, and ſo convey more nouriſhment to the plant, than the root alone could do. 2. To take in air; (of which more hereafter;) and 3. To miniſter to a kind of inſenſible perſpiration, by which redundancies may be thrown off.

9. The nutrition of plants ſeems to be performed thus. As the earth abounds with particles of every ſort, thoſe which ſuit each plant, being diſſolved by moiſture and agitated by heat, enter the root through its threads or pores, aſcend through the woody fibres, and being in the veſicles of the plant mixed with its native juice, and ſubtilized by fermentation, inſinuate themſelves into all parts of it. Part of this nouriſhes the plant and forms the fruit; the reſidue tranſpires. But as all particles are not equally fit to enter the pores of every plant, neither can all be fermented into a juice proper to nouriſh it: the reaſon is plain, why every plant will not flouriſh in every ſoil.

It is remarkable, that trees of very different kinds, draw their whole ſuſtenance from the moiſture they find in the ſame piece of ground, and from the ambient air and dews. Hence we may infer, that the very contexture of their bodies form the firſt ſeed, are the natural limbecs, where the common water and air, are digeſted into ſo many different leaves and fruits.

We ſee alſo, that a handful of moſs, ſometimes above a ſpan long, grows out of a ſmall oyſter-ſhell, without any earth, as do trees out of bare rocks. Hence we eaſily learn, that the ſeeds firſt, and then the roots, ſtems, and leaves of trees, are the ſtrainers which ſecrete and generate their peculiar ſaps and juices. Theſe are at firſt little elſe than pure air and water, till they are concreted in peculiar ſalts, by more curious ſtrainers, and more ſubtile boilers than art has ever adviſed.

10. The ancients generally ſuppoſed the earth to produce vegetables; many of the moderns aſcribe it to water alone. But it is a doubt whether the experiment was made with the nicety that is requiſite. And it proves nothing, unleſs that water be quite pure from

any

any terreſtrial mixture. For if it be not, the plant may owe its whole growth to that terreſtrial matter.

Who can find any water, newly taken out of the ſpring, which does not exhibit even to the naked eye, great numbers of ſmall terreſtrial particles, diſperſed through every part of it? Theſe are of two general kinds. Some are of a mineral nature, others of a vegetable. Of the latter ſome are fit to nouriſh one plant, or one part of it, and ſome another. All water is much charged with vegetable matter, which is fine, light, and eaſily moveable. Spring water contains leſs of it than river water, river water more than rain water.

To which of theſe waters, or the matter ſuſtained therein, do vegetables owe their growth? In order to decide this, the following experiments were made. Several phials of the ſame ſhape and ſize were filled with equal quantities of water. Over each was tied a piece of parchment, with a hole in it juſt large enough for the ſtem of the plant, to prevent the water from evaporating, or aſcending any way but through the plant. Several plants being exactly weighed, were then placed in theſe phials, and as they imbibed the water, more was added from time to time. Each glaſs was marked with a different letter, and all ſet in the ſame window, from July 20, till October 1. Then they were taken out, the water in each phial weighed, and the plant with the leaves that had fallen off. It then appeared how much each plant had gained, and how much water had been expended upon it.

Letters on the glaſſes.	Weight of the plant put in	Weight when taken out.	Weight gained in 77 days.	Expenſe of water.	Proportion of the increaſe to the expenſe of water.
	gr.	gr.			
A. Spear-mint ſet in ſpring-water.	27	42	15	2558	1 to 170
B. Spear-mint in rain-water.	28	45	17	3004	1 to 171
C. Spear-mint in Thames-water.	28	54	26	2493	1 to 95
D. Night-ſhade in ſpring-water.	49	106	57	3708	1 to 65

The water aſcends through the veſſels of plants, as through a filtre. And a larger filtre draws more water than a ſmaller. Therefore plants that have more or larger veſſels, draw more than thoſe that have fewer and ſmaller.

But the greateſt part of the water imbibed by plants, paſſes through their pores, into the atmoſphere. Hence the leaſt proportion of water expended is to the increaſe of the plant, as 46 or 50 to one In ſome it is 100, 200, nay in one, 700 times as much as the increaſe of the plant.

Nor does this water paſs off alone, but bears with it many particles of the plant. The groſſer indeed are not ſo eaſily borne up into the atmoſphere, but are uſually depoſited on the ſurface of the flowers, leaves, or other parts of the plant. Hence our honey-dews, and other gummous exudations. But the finer eaſily aſcend into the atmoſphere, and are conveyed to our organs for ſmell.

Great part of the terreſtrial matter mixt with the water aſcends into the plants. After the experiment, there was much more of it in the glaſſes which had no plants in them, that in thoſe that had. Indeed, this matter,

matter, being ſo fine and light, attends water in all its motions: ſo that filtre it ever ſo often, ſome will remain.

The plant increaſes more or leſs as the water it ſtands in, contains more or leſs of this matter. So the mint in the glaſs C. was of much the ſame bulk and weight with thoſe in A. and B. But ſtanding in river-water, which contained more terreſtrial matter, than the ſpring or rain water wherein they ſtood, it increaſed almoſt double to either of them, yea, and with leſs expenſe of water.

But all vegetable matter is not proper for the nouriſhment of every plant. Although ſome parts in all may owe their ſupply to the ſame common matter, yet others require a peculiar ſort of matter, and cannot be formed without it. Yea, different ingredients go to the compoſition of one and the ſame plant. If therefore the ſoil wherein a plant is ſet, contains all, or moſt of thoſe ingredients, it will grow there, otherwiſe not. If there be not as many ſorts of particles, as are requiſite for the eſſential parts it will not grow at all. If they be there, but not enough of them, it will not grow to its natural ſtature. If the leſs eſſential particles be wanting, it will be defective in ſmell, taſte or ſome other way. But though ſome land may not contain matter proper for ſome plants, yet it may for others. All this ſhews, that plants owe their increaſe, not to water only, but to a particular terreſtrial matter: elſe there would be no need of manure, or of tranſplanting them from place to place. The rain falls on all places alike: on this field and that, this garden or orchard and another. Vegetables therefore are not formed of water. One plant drew up 2501 grains of this; yet increaſed only three grains and a half. The mint in B. took thirty-nine grains of water a day, which was much more than the whole weight of the original plant. And yet it gained not one fourth of a grain in a day and night.

Water then is only a vehicle to the terreſtrial matter, which forms vegetables. Where this is wanting, the plant does not increaſe, though ever ſo much water aſcend into it. This is only the agent which conveys that matter to them, and diſtributes it to their ſeveral

parts

parts for their nouriſhment. It is fitted for this office by the figure of its parts, which are exactly ſpherical; therefore eaſily ſuſceptible of motion, and conſequently capable of conveying other matter that is not ſo voluble. Beſide, the conſtituent particles of water are abſolutely ſolid, and do not yield to the greateſt external force: therefore their intervals are always alike. By this quality water is diſpoſed to receive matter into it: by the former, to bear it along with it.

It is farther qualified to be a vehicle of this matter, by the fineneſs of its particles. We ſcarce know a fluid in nature, except fire, whoſe conſtituent parts are ſo exceeding ſmall. They paſs pores which air itſelf cannot paſs. This enables them to enter the fineſt veſſels of plants, and to introduce the terreſtrial matter to all parts of them; each of which, by means of peculiar organs, aſſumes the particles ſuitable to its own nature, letting the reſt paſs on through the common ducts.

II. As to the motion of the nutritive juice ſome think it aſcends by the wood, and deſcends by the bark. But it is not eaſy to ſhew, by what particular tubes it either aſcends or deſcends. Neither after all our reſearches does it appear, what is the principle of this motion. Whether there be any ſuch thing as an attractive force in the plant itſelf: or whether it be performed on the mere principles of mechaniſm, by the expanſion of the air contained in the juice, which moves and propels the particles of it into every part of the plant.

However, that the ſap in plants does circulate is made probable by an eaſy experiment. On a branch of a plain jeſſamine, whoſe ſtem ſpreads into two or three branches, inoculate in Autumn, a bud of the yellow ſtriped jeſſamine. When the tree ſhoots the next ſummer, ſome of the leaves will be ſtriped with yellow, even on the branches not inoculated. And by degrees, the whole tree will be ſtriped, yea, the very wood of the young branches.

It is probable the circulation is performed thus. The wood of plants conſiſts of fine, capillary tubes, which run parallel with each other from the root, and may be

be looked upon as arteries. On the outſide of theſe, between the wood and the inner bark, are larger tubes, which may do the office of veins. Now the root having imbibed juice from the earth, this is put into motion by the heat. Hereby it is rarified and cauſed to aſcend in the form of a ſteam or vapour; till meeting the mouths of the arterial veſſels, it paſſes through them to the top, and to the extreme parts of the tree with a force anſwerable to the heat whereby it is moved. When it arrives there, meeting with the cold of the external air, it condenſes into a liquor, and in that form returns by it own weight to the root of the venal veſſels.

12. That the ſap does circulate, appears farther from hence, that the graft will either corrupt or heal the ſtock. Nay, it changes the very way of the growing of the root, which it could not do, but by ſending down its ſap thither. Crab-ſtocks grafted with fruit, which the ſoil does not like, will canker, not only in the graft, but the ſtock alſo. But graft them again with fruit it does like, and it will quickly heal. Farther: graft twenty young pear-ſtocks with one ſort of pear, and twenty with another. The roots of one ſort will grow all alike, and ſo will thoſe of the other. Yet ever-greens grafted on trees which drop their leaves, as the ever-green oak of Virginia upon the common Engliſh oak, hold their leaves all the winter. Does not this ſhew, that the juices circulate in winter, as well as ſummer, even in the plants which drop their leaves? Otherwiſe thoſe grafted on them muſt ſoon die.

It ſeems that the ſap does not riſe by the pith: becauſe ſome large trees are without that part, and yet continue to put forth branches. Indeed no pith is found in thoſe branches of a tree, which exceed two or three years growth. And the pith which is in a branch of this year, is diſtributed into thoſe boughs which are formed the next ſeaſon.

Many believe, the tree does not receive its nouriſhment by the bark; becauſe trees that have loſt that part, continue to grow. But they ſuppoſe a tree has but one bark: whereas every branch has four diſtinct coverings. The two outermoſt of theſe may be taken

from

from a tree without much damage. But if the two others be taken off, it will infallibly kill the tree.

Some affirm, that the ſap neither riſes nor falls in the woody part of the tree, becauſe when a branch is cut, they cannot diſcern any ſap iſſue out of it. Certainly they cannot; becauſe thoſe tubes are not large enough, to receive any thing more groſs than vapour. The root receives chiefly in autumn its proper juices, which the warmth in ſpring raiſes into a vapour, that gradually aſcends through thoſe fine tubes, and by that means cauſes vegetation.

13. Some have objected to our Lord's ſpeaking of corn increaſing a hundred fold, that this is impoſſible. So far from it, that a grain of barley, has been known to produce two hundred and forty-nine ſtalks, containing above eighteen thouſand grains.

A ſtill more curious experiment was made with turnip ſeed, at Sutton-Coldfield, in Warwickſhire. In leſs than three days after it was ſown, the turnips were above ground. In three weeks the roots were as big as walnuts: in leſs than five weeks, as large as apples. Auguſt 12th, one of them weighed two pounds fourteen ounces. At the ſame time was weighed an ounce of the ſeed, which had been ſown, and it was found to contain fourteen thouſand ſix hundred ſingle grains. This being multiplied by forty-ſix (the ounces that the turnip weighed) produces ſix hundred and ſeventy-one thouſand ſix hundred, viz. the number of ſingle grains required to equal the weight of the turnip. Hence it follows, that (ſuppoſing the increaſe was uniform) the grain when it was ſown, weighing but $\frac{1}{14600}$th of an ounce, increaſed in the following proportions:

In ſix weeks	671600	Times its own weight.
A week	111933	
A day	15990	
An hour	660	
A minute	11	

In June 1766, Mr. Miller ſowed ſome grains of common red wheat. On Auguſt 8, a plant was taken up and

and divided into eighteen parts. Each of theſe was placed ſeparately. Theſe plants having ſhot out ſeveral ſide ſhoots, by the middle of September, they were taken up and divided again. This ſecond diviſion produced ſixty-ſeven plants. Theſe remained through the winter. Another diviſion of them made in the ſpring, produced 5000 plants. They were then divided no farther.

The whole number of ears, which by the proceſs were produced from one grain, was 21109. And from a calculation made, by counting the whole number of grains in one ounce, might be about 576840.

14. Some plants are male and ſome female. Mr. Miller ſeparated the male-plants of Spinach, from the female. The ſeed ſwelled as uſual, but did not grow when he ſowed it. Yet it might have been impregnated another way, as appeared from another experiment. He ſet twelve tulips about ſix yards from any other, and as ſoon as they flowered, carefully took out the ſtamina. Two days after he ſaw bees working on other tulips, and coming out loaded with the duſt. They flew into the firſt tulips, and left therein duſt enough to impregnate them, which accordingly bore good ſeed. Thus we ſee the farina may be carried by inſects, and lodged on flowers, which it is fit to impregnate.

Afterwards he bought and ſowed ſome ſavoy ſeed, and planted out the plants, but was ſurpriſed at the production. For he had ſome red cabbage, ſome white, ſome ſavoys with red ribs, and ſome a mixture of all together in one plant. The gardener aſſured him, he had carefully ſaved the ſeed. Being aſked, where he had ſet the plants for ſeed, he ſhewed him, and ſaid, he planted firſt a dozen white cabbages, next a dozen ſavoys, and then a dozen red cabbages. Is it not plain that here the effluvia of one ſort, impregnated the other? For did each grain of the farina impregnate only its own kind, this mongrel ſort could never be produced.

An inſtance of the ſame kind has been obſerved with regard to Indian corn: this is of ſeveral colours, as white, red and yellow. If each of theſe be planted by themſelves,

themſelves, they produce their own colour. But if you plant the blue corn in one row, and the white or yellow in the next, they will interchange colours: ſome of the ears in the blue corn-rows, are white or yellow, and ſome in the white or yellow rows, are blue. That this is cauſed by the effluvia of one impregnating the other, is manifeſt from hence. Place a cloſe, high fence, between the corn of different colours, and there is no change of colour in any of them.

The holly is deſcribed by all naturaliſts, as bearing hermaphrodite flowers. But by late obſervations it has appeared, that ſome trees bear male, ſome female flowers. Yet there is a vaſt variety. In Chelſea-garden, ſome hollies bear female, ſome hermaphrodite flowers. But ſome trees bear only male flowers; ſome only female, ſome only hermaphrodite. Others bear both male and female, both male and hermaphrodite, or female and hermaphrodite. And others bear male, female, and hermaphrodite, all at the ſame time.

15. That the leaves of certain plants aſſume at night a diſpoſition different from that of the day, is well known. This has been uſually termed, the ſleep. But to what is this owing? Not to the variation of heat or cold, moiſture or dryneſs. For however theſe are varied, the ſame thing happens with equal regularity. It is light alone that occaſions this change, which by the ſmallneſs of its particles, is capable of entering bodies, and by its activity, of producing great changes in them. It changes the poſition of the leaves of plants, by a motion it excites among the fibres. The natural poſition of the lobes in theſe leaves is drooping. This is their poſture of repoſe. But vegetation is very imperfectly performed, while they remain in it. It is light which alters that poſition, by its quick vibrations.

In the evening, Auguſt 7, (in order to make a full experiment) Dr. Hill placed a plant of Abrus, in a room where it had moderate day-light, without the ſun ſhining upon it. The lobes of the leaves were then fallen perpendicularly from the middle rib, and cloſed together by their under ſides. Thus they continued all night. Half an hour after day-break, they began to ſeparate, and a quarter of an hour after ſun-riſe, were perfectly expanded. Long before ſun-ſet they began

gan to droop again, and toward evening were closed as at first.

Next day the plant was set, where there was less light. The lobes were raised in the morning, but not so much. And they drooped earlier at evening.

The third day it was set in a south window, open to the full sun. Early in the morning the leaves had attained their horizontal situation: by nine o'clock they were raised above it, and continued so till evening. Then they fell to the horizontal situation, and thence gradually to the usual state of rest.

The fourth day the plant stood in the same place, but the sun did not appear. The lobes early attained their horizontal situation, but did not rise beyond it, and in the evening closed as usual.

These experiments prove, that the whole change is occasioned by light only. To put this beyond dispute, in the evening of the sixth day, the plant was set in a book-case, on which the morning sun shone, the doors standing open. The next day was bright. The lobes which had closed in the evening, began to open early in the morning, and by nine o'clock they were raised in the usual manner. I then shut the doors of the book-case: on opening them an hour after, the lobes were all closed as at midnight. On opening the doors, they opened again, and in twenty minutes they were fully expanded. This has since been many times repeated, and always with the same success. We can therefore, by admitting or excluding the light, make the plant put on all its changes. Hence we are certain, that what is called the sleep of plants, is caused by the absence of light alone, and that their various intermediate states are owing to its different degrees.

It has been supposed that the daily motions of the sensitive plant, were likewise owing to light and darkness; because it expands itself in the morning, and closes again in the evening. From the main branches of this plant spring several smaller ones, and from these others still less, which support the leaves ranged on each side, in pairs over against one another. Several other plants are of the same form, and all these close their leaves in the evening, and open them in the morning, which therefore is not peculiar to the sen-

sitive

ſitive plant. But this cloſes them at any time of the day, if touched, and ſoon after opens them again. You can ſcarce touch the leaf of a vigorous ſenſitive plant ſo lightly, as not to make it cloſe. The large rib which runs along its middle, is as an hinge on which the two halves of the leaf move, when they turn upon being touched, till they ſtand erect, and by that means meet one another. The ſlighteſt touch gives this motion to one leaf; if a little harder, it gives the ſame motion to the leaf oppoſite. If the touch be ſtill rougher, the whole arrangement of leaves on the ſame rib cloſe in the ſame manner. If it be ſtronger ſtill, the rib itſelf moves upward toward the branch on which it grows. And if the touch be yet more rough, the very branches ſhrink up toward the main ſtem. The motion which has the greateſt effect of all others upon it, is the ſhaking one. Winds and heavy rain alſo cauſe this plant to cloſe its leaves; but not gentle ſhowers: the contraction being cauſed by the agitation of the wind, and the ſtrokes given by the large drops.

The natural ſhutting and opening of its leaves at night and morning, are not ſo fixed, as not to be variable by many circumſtances. In Auguſt, a ſenſitive plant was carried in a pot into a dark cave. The ſhaking in the carriage ſhut up its leaves, ſo that they did not open for four and twenty hours. And when they did open, they cloſed no more for three days and nights. Being then brought again into the open air, they recovered their natural motions, ſhutting at night and opening in the morning, as regularly as ever. While in the cave, it was as much affected by the touch, as in the open air.

By this and many experiments it appears, that it is not the light that opens theſe plants, nor the darkneſs which ſhuts them. Neither is it owing to the increaſe of heat or cold. Indeed, great heat will affect them a little, but not in any conſiderable degree. Concerning the real cauſe, we may form many conjectures: but nothing certain can be known.

Nearly related to the ſleep of plants, is that which Linnæus calls the awaking of flowers. The flowers of moſt plants, after they are once opened, continue ſo

night and day, until they drop off, or die away. Others, which ſhut in the night-time, open in the morning ſooner or later, according to their ſituation in the ſun or ſhade, or as they are influenced by the manifeſt changes of the atmoſphere. There is another claſs of flowers, which make the ſubject of theſe obſervations, which obſerve a more uniform law in this particular.

Theſe open and ſhut conſtantly at certain hours, excluſive of any manifeſt changes in the atmoſphere; and this with ſo little variation in point of time, as to render the phenomenon worth obſervation. Linnæus's obſervation extends to near fifty ſpecies which are ſubject to this law. We will enumerate ſome of theſe, and mention the time when the flowers open and ſhut. The little blue convolvulus, or bindweed, opens its flowers between five and ſix in the morning, and ſhuts them in the afternoon. The flowers of the day-lilly open about five in the morning, and ſhut at ſeven or eight in the evening. The leſſer water-plantain, during its flowering-time, only opens its flowers each day about noon. The flowers of the proliferous pink, expand about eight in the morning, and cloſe again about one in the afternoon. Purple ſpurrey, expands between nine and ten in the morning, and cloſes between two and three in the afternoon. This little plant is common among the corn in ſandy ſoils and flowers in June. Common purſlain opens its flowers about nine or ten in the morning, and cloſes them again in about an hour's time. The white water-lilly grows in rivers, ponds and ditches, and the flowers lie upon the ſurface of the water. At their time of expanſion, which is about ſeven in the morning, the ſtalk is erected, and the flower more elevated above the ſurface. In this ſituation it continues till about four in the afternoon, when the flower ſinks to the ſurface of the water, and cloſes again. Yellow goat's-beard, or go-to-bed-at-noon (the latter of theſe names was given to this plant long ſince, on account of this remarkable property) opens its flowers in general about three or four o'clock, and cloſes again about nine or ten in the morning. Theſe flowers will perform their vigiliæ, if ſet in a phial of water, within doors, for ſeveral mornings ſucceſſively.

Some-

Sometimes they are quite closed, from their utmost state of expansion, in less than a quarter of an hour.

16. From what has been said it plainly appears, that there is a considerable agreement between plants and animals, as well with regard to their nutrition, as to the structure of their parts. Some extend this farther, and think there is something in plants answerable to respiration in animals. They suppose the spiral fibres to be in the place of lungs, and to serve this very purpose: that in each of these there is a spiral lamina, which is extended or contracted, as it is impelled this way or that, by the elastic air it includes: that these fibres ascending strait through the trunk, are dispersed through all the branches, and thence into the leaves, where they are woven together in a kind of net-work. By this means the more subtle parts of the air are strained through those spiral fibres, to keep the juices of the plant fluid, and perhaps to supply them with nitre or æther, to assist their fermentation.

The air enters vegetables various ways, by the trunk, leaves, roots and branches. For the reception as well as expulsion of it, the pores are very large in some plants. So one sort of walking canes seem full of large pin-holes, resembling the pores of the skin in the ends of our fingers. In the leaves of the pine, if viewed through a glass, they make an elegant show, standing as it were, in rank and file, throughout the length of the leaves.

Air vessels are found in the leaves of all plants, and in many are visible to the naked eye. For on breaking the chief fibres of the leaf, the likeness of a fine woolly substance, or rather of curious, small cobwebs, may be seen to hang at both the broken ends. Now these are the fibres of the air vessels, loosed from their spiral position, and drawn out in length.

The pores in the leaves of plants are almost innumerable. Mr. Lewenhoek found above a hundred and seventy-two thousand, on one side of a leaf of box. The leaves of rue are as full of holes as a honeycomb. Those of St. John's wort likewise appear full of pin-holes to the naked eye. But the places where

thoſe holes ſeem to be, are really covered with a thin and white membrane. Through a microſcope the backſide of the herb Mercury, looks as if rough with ſilver; and all the ribs are full of white, round, tranſparent balls, faſtened by ſlender ſtalks, like ſo many grapes. A ſage-leaf appears like a rug or ſhag, full of tufts of ſilver thrumbs, and embelliſhed with round cryſtal beads, faſtened by tender foot-ſtalks. The prickles of a nettle are formed for acting juſt as the ſting of animals. Every one of them is hollow, and terminates in a fine point, with an opening near its end. At the bottom of each prickle lies a pellucid bag, containing a clear liquor, which upon the leaſt touching the prickle, is ejected at the little outlet, and if it enters the ſkin, cauſes pain and inflammation by the pungency of its ſalts.

The leaves of plants are of great conſequence to their life. At theſe the air paſſes in, and goes through the whole plant, and out again at the roots. If the leaves have no air, the plant will die, as is eaſily proved by the air-pump: whereas if the leaves be left on the outſide of the receiver (parted by a hole cemented by wax) while theſe have air, the plant will thrive and grow, though its roots and ſtalks are kept in vacuo. The leaves likewiſe chiefly perform the neceſſary work, (but who can explain the manner!) of altering the water received at the root, into the nature of the juices of the plant. And hence it is, that the life of plants depends ſo immediately upon their leaves. The huſbandman often ſuffers for want of this knowledge. A crop of ſaint-foin is valuable; and its roots being perennial, will yield an increaſe for many years. But it is often deſtroyed at firſt, by ſuffering it to be fed upon by ſheep. For if they eat up all the leaves, the root cannot be ſupplied with air, and ſo the whole periſhes. Leaves being ſo neceſſary to all perennial plants, a reverſionary ſtock of them is provided. The leaves of theſe plants are always formed in Autumn, though not unfolded till the following ſpring. They then open and increaſe in proportion to the motion of the ſap, and the quantity of nouriſhment the plant receives. Theſe leaves alſo, though not yet appearing out of the bud, may ſuffice for the extremely ſmall motion,

motion, which the ſap of thoſe perennial plants, that drop their leaves, has in winter.

But beſides theſe autumnal leaves, there is another ſet formed in ſpring and expanding till mid-ſummer. Theſe are of infinite ſervice to many ſort of trees, particularly to the mulberry, as they ſave its life, when the firſt ſet of leaves have been all eaten by the ſilk-worms.

The analogy between the parts of plants and thoſe of animals may now more fully appear. The parts of plants are, 1. The root, compoſed of abſorbent veſſels, analogous to the lacteals in animals: indeed performing the office of all thoſe parts of the abdomen, that miniſter to nutrition: 2. The wood compoſed of capillary tubes running parallel from the roots, although the apertures of them are commonly too minute to be ſeen. Through theſe, which are analogous to arteries, the ſap aſcends from the root to the top: 3. Thoſe larger veſſels, which are analogous to veins. Through theſe it deſcends from the top to the root. 4. The bark, which communicates with the pith by little ſtrings, paſſing between the arteries. 5. The pith, conſiſting of tranſparent globules, like the bubbles that compoſe froth.

The ſap enters the plant in the form of pure water, and the nearer the root, the more it retains of that nature. The farther it goes, the more it partakes of the nature of the plant. In the trunk and branches it remains acid. In the buds it is more concocted. It is farther prepared in the leaves, (as blood in the lungs) which being expoſed to the alternate action of heat by day, and cold by night, are alternately dilated and contracted.

Is not then the motion of the ſap in plants, (like that of the blood in animals) produced chiefly by the action of the air? All plants have the two orders of veſſels. 1. Thoſe which convey the nutritious juices. 2. Air-veſſels, hollow tubes, within which all the other veſſels are contained. Now the leaſt heat rarefies the air in theſe air-veſſels, thereby dilating them, and ſo cauſing a perpetual ſpring, which promotes the circulation of the juices. For by the expanſion of the air-veſſels, the ſap-veſſels are preſſed, and the ſap continually

tinually propelled. By the ſame propulſion it is comminuted more and more, and ſo fitted to enter finer and finer veſſels: while the thicker part is depoſited in the lateral cells of the bark, to defend the plant from cold, and other injuries.

Thus is every plant acted on by heat in the daytime, eſpecially in ſummer: the ſap protruded, then evacuated, and then exhauſted. In the night the air-veſſels being contracted by the cold, the ſap-veſſels are relaxed, and diſpoſed to receive freſh food for the next day's digeſtion. And thus plants do, as it were, eat and drink, during the night-ſeaſon.

The veſſels themſelves conſiſt of mere earth, cemented by oil and water: which being exhauſted by fire, air, or age, the plant returns to its earth. Thus in plants, burnt by the fierceſt fire, the matter of the veſſels is left entire; which conſequently is neither water, air, ſalt, nor ſulphur, but earth alone. The ſap conſiſts of ſome ſaline parts: others derived from air, rain and putrified plants or animals. Conſequently in plants are contained, ſalts, oils, water, earth: and probably all metals too. In fact, the aſhes of all vegetables yield ſomething, which the loadſtone attracts.

There is a conſiderable difference as to the time when different plants revive after the winter. No ſooner does the ſun begin to warm the earth, than the vernal flowers appear, and the trees, one after another, open their buds, and clothe themſelves with leaves. But why do many wood-plants, as colts-foot, pile-wort, violets; and many garden-plants, as ſnow-drops, aſara-bacca, crocus, flower in the very beginning of ſpring, when we cannot by any pains or care, bring them to flower after the ſummer ſolſtice? Nay, theſe very plants, which are ſo patient of cold in ſpring, are in the autumn ſo very weak and tender, that they die on the firſt touch of froſt. Why on the contrary, do thiſtles and many other plants, never flower before the ſummer ſolſtice?

In the ſame manner trees obſerve fixed laws, and a certain order in their leafing. Does the cauſe lie in the different depth of their roots? If ſo, ſhrubs would have leaves before trees of the ſame kind. But they have

have not. We can only ſay, the fact we know; but the reaſon of it we know not.

The order of the leafing of ſeveral trees and ſhrubs, obſerved in Norfolk, in 1755, was as follows.

1.	Honeyſuckle, —	January 15.
2.	Gooſeberry, currant, elder,	March 11.
3.	Birch, weeping-willow, —	April 1.
4.	Raſberry, bramble, —	— 3.
5.	Briar, — —	— 4.
6.	Plumb, apricot, peach, —	— 6.
7.	Filbert, ſallow, alder, —	— 7.
8.	Sycamore, — —	— 9.
9.	Elm, quince, — —	— 10.
10.	Marſh-elder, — —	— 11.
11.	Wych-elm, — —	— 12.
12.	Horn-beam, — —	— 13.
13.	Apple-tree, — —	— 14.
14.	Abel, cheſnut, —	— 16.
15.	Willow, — —	— 17.
16.	Oak, lime, — —	— 18.
17.	Maple, — —	— 19.
18.	Walnut, plane, black poplar, beech,	— 21.
19.	Aſh, Carolina poplar, —	— 22.

Indeed the leafing of ſeveral of theſe varies much, as the ſpring is earlier or later. But others of them, be the winter ever ſo mild, do not put out before their time. This alſo depends on ſome ſecret properties, which man is not able to explain.

17. As to the generation of plants, firſt the tree produces buds, which afterwards expand into leaves, flowers, or branches. In the buds, entire plants are contained. A ſmall ſtalk, conſiſting of woody and ſpiral fibres, ſprings out of the middle of the plant, wherein the bud inheres. It is involved in a thin bark, which may be divided into various leaves, lying one upon another like ſcales.

18. Buds are followed by leaves and flowers. In flowers we may conſider, 1. The calix or outer cup, deſigned to be a ſecurity to the other parts of the flower.

Thoſe

Thoſe whoſe leaves are firm and ſtrong, as tulips, have no calix at all. Carnations, whoſe leaves are ſtrong but ſlender, have a calyx of one piece. Others have it conſiſting of ſeveral pieces, and in divers rounds. 2. The foliation or petala, the flower-leaves, which are properly the flower itſelf. In theſe, not only the admirable beauty, and luxuriant colours are obſervable: but alſo their curious folding in the calix, before they are expanded.

It is remarkable, that many, if not moſt vegetables, eſpecially thoſe of a tender kind, expand their flowers, or down, every day, if it be warm, ſunſhiny weather. But they cloſe them as the evening approaches: and ſome, at the approach of rain. This is particularly done at the beginning of flowering, while the ſeed is young and tender: as is eaſily ſeen in the down of dandelion, and eminently in the flower of pimpernel. Theſe ſerve as a weatherglaſs to the countryman: by the opening or ſhutting of theſe, he can tell without any danger of being deceived, whether the weather will be foul the next day.

The flower is as it were the womb, which contains the eggs or ſeeds of plants, and in due time brings them forth. It is near the bud, and lies hid with it during the winter, till it is brought out by the heat of the ſummer. The moſt ſimple plants bear a bud, which contains a ſeed of an oval figure. We may eaſily diſtinguiſh from the flower itſelf, the leaves of the covering which involves the bud. From theſe ariſe the leaves of the flower, ſerving for the laſt concoction of the ſap; in which are both woody and ſpiral fibres with various rows of utricles. In the middle of flowers filaments and little pillars ariſe, whoſe extremities are covered with a kind of duſt. Theſe pillars are hollow, and have veſicles full of liquor, and the rudiments of ſeeds, which gradually grow and harden.

That duſt is of two kinds, male and female. The male duſt is formed in the top of the filaments, where, when it is ripe, it burſts its caſe, and is ſplit on the heads of the pillars, and thence conveyed to the utricle or matrix thereof, to impregnate the female duſt contained therein.

This

This duſt in any one plant being viewed with a microſcope, every particle is of the ſame ſize and figure. But in different plants, the colour, ſize, and figure are widely different. In ſome it is clear and tranſparent, as cryſtal: in others white and opake: in ſome blue, purple or red, and in others, fleſh-coloured. And its colour varies in the ſame ſpecies, ſuppoſe tulips, according to the colour of the flower.

The moſt general figure is the oval, more or leſs ſharp at the ends, with one or more furrows running lengthways. But the ſeeds of melilot are cylinders, thoſe of the panſy are priſms, with four irregular ſides. Others repreſent two cryſtal globules faſtened together. Thoſe of the jonquille are in the form of a kidney. But indeed the varieties are not poſſible to be numbered. The office of the bloſſom is partly to protect, partly to draw nouriſhment to the embryo, fruit or ſeed. The gourd, pumkin, melon, cucumber, and moſt bearing trees, have both male and female bloſſoms on the ſame plant. Male bloſſoms, (uſually called cat-ſkins) may be diſtinguiſhed from female, by having no piſtil or rudiment of fruit about them; but only a large thrum, covered with duſt in their middle. The female bloſſoms have always a piſtil within the flower-leaves; and the rudiments of the fruit are always apparent at the bottom of the flower, before it opens.

But there is a ſpecies of willow, which appears to change its ſex every year. One year it produces male bloſſoms, and female bloſſoms the next.

19. The ſeed, when it is ripe, is encloſed in a peculiar covering. In ſome plants it ſo increaſes, as to become a fruit. And in theſe alſo we find fibres and utricles diſperſed with endleſs variety.

Various are the methods which the wiſdom of God takes for ſowing ſeeds of various kinds. Thoſe of arum and poppy are heavy enough to fall directly to the ground. Others that are light, have hooks to ſtop them, from ſtraying too far from their proper place. So have agrimony and gooſe-graſs. the one wanting a warm bank, the other a hedge for its ſupport.

On the other hand many ſeeds have wings, that

the wind may carry them off the plant, and may ſcatter them aſunder, that they may not fall together, and come up too thick. The kernels of pines have very ſhort wings, juſt enabling them to flutter on the ground. But ſome ſeeds have many long feathers, by which they are wafted about every where.

Others are lodged in elaſtic caſes, which dart out the ſeed to the convenient diſtances Thus wood-ſorrel having a running root, needs to have its ſeed ſown diſtant from each other. And this is done by means of a tendinous cover, which when it begins to dry, burſts open on one ſide in an inſtant, and is violently turned inſide out. The ſeed of harts-tongue is diſperſed in a different manner. It has a ſpring wound round its caſe. When it is ripe, this ſuddenly breaks the caſe in two halves, and ſo throws out the ſeed. Equally remarkable is the way wherein fern-ſeed is ſcattered. If a quantity of this be laid on a paper, the ſeminal veſicles burſt, and are ſeen by a microſcope projecting the ſeeds to a conſiderable diſtance.

The ſeeds of the ſeveral ſpecies of fern were wholly unknown to the ancients. But it is now well known, that in the female fern, the whole ſurface of the leaf on the underſide is covered with a congeries of ſeeds, ſo that they guard one another, and need no other covering. And in the common male fern, there are found at the proper ſeaſon, ſeveral brown ſpots, placed in a very regular manner. Theſe are a fungous matter, round which the ſmall ſeed veſſels are inſerted.

The fruitfulneſs of plants, in producing ſeeds, tranſcends all imagination. An elm living a hundred years, ordinarily produces thirty-three millions of ſeeds. Add, that if its head be cut off, it puts forth as many branches within half an inch of the place where it was cut as it had before. And to whatever height it is cut off, the effect will be the ſame. Hence it appears, that the whole trunk, from the ground to the riſe of the branches, is full of embryo branches, each of which will actually ſpring forth, if the head be lopped off juſt over it. Now if theſe had ſprung out, they would have borne an equal number of ſeeds

with

with thoſe that did. Theſe ſeeds therefore are already contained in them: and if ſo, the tree really contain 15840000000 ſeeds, wherewith to multiply itſelf as many times. But what ſhall wr ſay, if each ſeed contains another tree, containing the ſame number of ſeeds? And if we can never come, either at a ſeed which does not contain trees, or a tree which does not contain ſeed?

Timber trees of any kind might certainly be planted to more advantage than they generally are. There is a foreſt two miles from St. Leo in Normandy, planted chiefly with oaks, many of which are but of a moderate height, though of a large circumference. But near its entrance from St. Leo, there is a plantation, about twenty-five years old, wherein none of the oaks are under ſeventy, and ſome a hundred feet high. They are ſet ſo cloſe, that they almoſt ſeem to touch one another, and are no more than four or five inches in diameter. This timber is of great uſe, both for making charcoal, and many other purpoſes; and the owners may reap four crops of them in a hundred years.

This foreſt belongs to the king of France, who ordered the plantation to be made by way of trial; and his miniſters have cauſed ſeveral of the trees, a hundred feet high to be tranſplanted, to leave ſtanding proofs of the wonderful effects of the experiment.

As to ſowing, the perfection of agriculture conſiſts in ſetting plants at due diſtances, and giving a ſufficient depth to the roots, that they may ſpread and receive due nouriſhment. Yet this is little regarded, but all ſorts of grain are ſown by handfuls caſt at random. By this means four parts in five of the ſeed is utterly loſt. To remedy this, a Spaniſh gentleman contrived an engine (deſcribed in the Philoſophical Tranſactions, under the name of the Spaniſh Sembrador) which being faſtened to the plow, the whole buſineſs of plowing, ſowing, and harrowing, is performed at once; and the grain is ſpread at equal diſtances, and equally deep in the furrow. An experiment being made, land which uſually produced five fold, by this

means

means produced ſixty-fold. One ſtalk is all that ſprings immediately from one grain: but on the ſides of this, near, if not within the ground, iſſue ſeveral lateral ſtalks. And ſome of theſe ſend forth roots, whence one or ſeveral other ſtalks ſpring, if they are early formed, the ſoil good, and the weather favourable. By this means one grain of wheat planted in a garden has produced ninety, yea a hundred ears. If then each ear, taking one with another, contains fifty grains, a ſingle grain may produce five thouſand. Nay, a gentleman in Yorkſhire, who made the experiment in his garden ſome years ago, counted upwards of eight thouſand grains, which ſprung from a ſingle one.

After all that has been ſaid and wrote for ſo many centuries, on the generation or propagation of plants and animals, a late author (to whom the French naturaliſts in general ſubſcribe) totally denies the whole, and cenſures all who pretend to diſcover any animalcula in the ſemen of animals. He will by no means allow, that every animal or plant, proceeds from an egg lodged in the parent plant or animal. On the contrary, he ſuppoſes, "there are in matter certain organical parts, diſpoſed for the formation of animal and vegetable ſubſtances, which by coalition conſtitute the firſt ſtamina of all animal and vegetable bodies. Theſe are ſimple, uniform, common to all, and conſequently to be found more or leſs in every portion of the nutritive juice. From thence they are digeſted, and when the ſubject becomes adult, ſecreted for the formation of the ſeed of every plant and animal. Theſe organical parts, moving when diſengaged, and thence imagined to be alive, are extremely ſimple in their compoſition, being perhaps, only elaſtic ſprings, more or leſs compreſſed, more or leſs diverſified in the direction of their force.

All microſcopic animals, ſo called, are indeed no other than ſuch organical particles. Seeds macerated in water, firſt diſunite into ſmall particles, which ſoon after move and ſeem alive, though they are not ſo. The ſame may be obſerved of the juices of animals, as mutton-gravy and the like. And as to the common imagination, that the male ſemen, while in the veſſels, contains millions of animalcula like tadpoles, it is certain,

tain, they are produced, after the evacuation of the fluid, and riſe from principles contained therein, by a real vegetation, and a ſubſequent change from the vegetable to the animal life.

" Semen immediately evacuated is an homo geneous fluid. In a few moments it begins to ſeparate, and after this a kind of vegetable filaments grow in it, and ſhoot out ramifications on every ſide. Theſe open and divide into moving globules, which trail after them ſomething like long tails; which are in truth only ſtrings of the viſcid matter, from among which the globules were ſeparated. By degrees the globules get rid of them, and then move at eaſe.

" This vegetable power of ſhooting into filaments, is in all animal and vegetable ſubſtances, down to the leaſt microſcopic point. And to this is really owing, all that is called animal life, in the fluids produced from vegetables.

" In all our obſervations on theſe ſubſtances, the whole quantity of matter, after a ſeparation of ſome volatile and ſaline parts, always divides into filaments, and vegetates into numberleſs zoophytes, which afterwards yield all the ſpecies of microſcopic animals. After this, thoſe ſuppoſed animals themſelves ſubſide to the bottom of the liquor, become motionleſs, reſolve into a gelatinous, filamentous ſubſtance, and then afford new zoophytes or animals of a ſmaller kind.

" Hence we may obſerve, that every animal or vegetable ſubſtance, advances as faſt as it can, to reſolve into one common principle, which is the ſource of all: a kind of univerſal ſemen, from which each atom may again aſcend to a new life. Theſe animalcula then in the ſemen of animals, and in the infuſions and juices of animal and vegetable ſubſtances, are not of the nature of any other beings, nor to be ranked with them. They conſtitute a claſs apart from all others, the characteriſtic of which is, that they neither are generated, nor ſubſiſt by nutriment, like other plants or animals, nor do they generate in the ordinary way."

What then becomes of this whole boaſted branch of modern philoſophy? If this be ſo, moſt of our microſcopic diſcoveries vaniſh into air.

Blue-

Blue-flowered gentianella requires wet weather to be ſown in. As ſoon as any rain touches the ſeed veſſels, they burſt open and throw the ſeed on each ſide. cardamines burſt their pods and dart out their ſeed on a light touch of the hand: nay, the cardamine impatiens does ſo, even by the approach of the hand. Other ſeeds by their agreeable taſte or ſmell, invite birds to feed upon them, who drop them again, fertilized by paſſing through their body. So miſtletoe is uſually ſown.

The berries of miſtletoe have within their viſcid pulp, a kernel covered with a thin, whitiſh ſkin. One placed theſe berries within the bark of oak, aſh, beech, pear, and apple-trees, by making ſeveral cuts in the ſides of the trees, but the whole berries would not ſtay in any of them. And when he broke them, the ſeed always ſlipt out to the edge of the cut, and there ſtuck to the bark by its viſcous covering. He ſtuck one ſeed to the bark without any cutting at all, which ſucceeded beſt, and yielded two plants. The viſcous matter drying away, drew the ſeeds cloſe to the bark, and on theſe with two more on an apple-tree and one on a pear-tree, there began in ſpring to ſhoot out at the end of the ſeed next the eye of the berry, a ſmall deep green ſhoot, like a little claſper of a vine. At firſt it roſe upward, then turning again, ſwelled out ſomewhat bigger round the end: yet leaving the tip quite flat, forming as it were a foot to ſtand upon. This foot in June came to the bark, and fixed itſelf thereon. Being thus faſtened at both ends, it formed a little arch, whoſe diameter was as long as the ſeed. Thus it remained till March following. Then the other end let go its hold, and raiſing itſelf upward became the head of the plant, while the end which ſprung out firſt, became the root. It is not uncommon, for the ſeeds of ever-greens to be two years before they ſpring out of the ground. But this was ſurpriſing, the change of the ends, firſt one ſhooting out, and then the other. Yet we find nature is uniform, and even in this ſtrange plant, acts as in other vegetables, firſt carrying the ſap to form the root, then turning the courſe of it back again, to ſend out the upper part of the plant. The ſtrangeſt circumſtance is, that the rooting end ſhould

firſt

firſt ſhoot into the air, and then turn down to find a place to fix on. This it is, which has kept the world ſo long in ignorance about the growing of this ſeed. For by requiring a new, ſmooth part of the bark whereon to fix the rooting part, it has fruſtrated all attempts of ſowing it as we do other ſeeds.

In ſtrawberries and raſberries the hairs which grow on the ripe fruit, are ſo many tubes leading to the ſeveral ſeeds. And therefore we may obſerve, that in the firſt opening of the flower, the whole inward area is like a little wood of theſe hairs: and when they have received and conveyed their globules, the ſeeds ſwell and riſe in a fleſhy pulp.

The manner wherein moſſes in general ſeed, is exceeding little underſtood. But in one ſpecies at leaſt, it may be clearly explained, from a number of obſervations. The head of this moſs appears to the naked eye, ſmooth and of a pale, brown-colour. The top of this is bounded by an orange-coloured ring, which is a calix, containing ſixteen pyramidal ſtamina, loaded with a white farina. Theſe bend towards each other, and when the head is nearly ripe, almoſt meet in a point at their tops. Immediately under the arch formed by theſe ſtamina, is placed a ſlender, hollow, piſtil, through which the farina makes its way, and is diſperſed among the ſeeds in the head. The external membrane of the head, is a continuation of the outward covering of the ſtalk. A ſection of the head ſhews, that this membrane includes a ſeed-veſſel ſo large as to fill it every way. This is filled with perfect and beautiful ſeeds. They are round and tranſparent when unripe, but afterwards they are opake, and of a beautiful green. The number of ſeeds in one of theſe heads, is not leſs than 13,800.

The ſeed-veſſels of mahogany trees are of a curious form. They conſiſt of a large cone, which ſplitting into five parts, diſcloſe their winged ſeeds. None would think, that ſo tall and ſo large trees, could grow on ſolid rocks. They are four feet and upwards in diameter. The manner of their growth is as follows. The ſeeds fly along the ſurface of the ground, and

and ſome falling into the chinks of the rocks, ſtrike root, then creep out upon the ſurface, and ſeek another chink. In this they ſwell to ſuch a ſize and ſtrength, that the rock ſplits and makes way for the root to ſink deeper. And with this little nouriſhment the tree in a few years grows to that ſtupendous ſize.

The progreſs of germination was accurately obſerved by Malpighi in the ſeed of a gourd. The day after it was committed to the ground, he found the outer coat a little ſwelled: and in its tip a ſmall cleft appeared, through which the ſperm was ſeen. The ſecond day the outward coat was much ſofter, the inner torn and corrupted, the germ ſomewhat longer and more ſwelled, and the beginning of the root appeared. The third day the root had made itſelf a paſſage through the coat, near the former cleft. The germ and ſeed-leaves alſo were now grown much bigger. On the ſixth more of the ſeed-leaves had broken through, and were found thicker and harder. The root had ſhot out many fibres, and the ſtem grown a finger's length. About the twenty-firſt day the plant ſeemed complete, from which time the ſeed-leaves began to droop, till they died away.

20. The parts of different fruits are different; but in all the eſſential parts of the fruit, are only continuations of the fibres, obſerved in the other parts of the tree. And there is a direct communication between the fruit and the remoteſt part of the tree. Thus an apple cut croſs-ways appears to conſiſt of four parts. Firſt the ſkin, derived from the outer bark of the tree. 2. The pulp, which is an expanſion of the inner bark. 3. Ramifications of the woody part of the tree, diſperſed throughout the pulp. To theſe are faſtened the coats of the kernels. And theſe being at firſt extended to the flower, part of them directly, and part obliquely, furniſh it with its nouriſhment. But the fruit increaſing intercepts the aliment: and then the flower is ſtarved and falls off. 4. The core, which is a production of the pith of the plant, ſtrengthened by fibres of the wood intermixed. This is a caſe for the kernels, filtrates the juice of the pulp, and conveys it to them.

Fruit ſerve not only for the food of animals, but

to guard and nourish the seed enclosed; to filtrate the coarser part of the nutritious juice, and transmit only the purest for the support and growth of the plantule.

In every sort of grain, wheat, barley, or any other, there are three particulars observable, 1. The outer coat, which contains all the rest. This in the same species of grain, is of a very different thickness in different years, as also in different soils. 2. The germ or bud. This is always hid in the grain, and is the plant in miniature. And 3. The meal, which is enclosed in the skin, that surrounds the germ, and gives it nourishment, when first put into the earth, before it is capable of drawing it from the earth itself.

The whole structure of the plant which produces these grains is equally admirable. The chaffy husk is well adapted to defend the grain, as long as that is necessary, and then to let it fall. The stalk, hollow and round, is at once light and strong, capable of sustaining the ear, without absorbing too much of the juices destined for its nourishment. And the beards are a defence against the birds, that would otherwise destroy the grain before it ripened. The covering of the grain is formed of fibres, which meet in a line and form a kind of furrow. This is the place at which the seed, when moistened, is to burst open. Were not these means prepared for the germ's coming out, the toughness of the outer coat, would have kept in both the meal and the germ, till they had rotted together.

Nor is this the only use of this place of opening. The grain is designed not only for seed, but for food also. Men have art enough to erect machines, for reducing it to powder. But the birds eat it as it is, and it would pass them whole without doing them any good were it not, that when it is moistened, it bursts open at the furrow and yields them nourishment.

The meal is composed of an infinite number of round, white, transparent bodies. These enclose the young plant, and by their figure being easily put in motion, as soon as affected by the heat and moisture of the earth, they insinuate into the vessels of the plant, and give it increase, till it is in a condition to feed on the juices of the earth. The same process of nature is observable,

obſervable, when grains of corn grow out of time, on being thrown careleſsly together, in a moiſt place.

21. Plants do likewiſe perſpire. To find the quantity imbibed and perſpired by plants, Dr. Hale took a pot with a large ſun-flower planted in it, and by various experiments found, the greateſt perſpiration in a very warm day, to be one pound fourteen ounces; the middle perſpiration one pound four ounces. It perſpired three ounces in a warm night, when there was no dew. If ſmall dew fell, it perſpired nothing, if a large dew it gained two or three ounces.

The weight of the flower was three pounds: the weight of a well-ſized man is one hundred and ſixty. The flower perſpires twenty-two ounces in twenty-four hours: the man about twenty-five; (beſide ſix ounces, which are carried off by reſpiration from the lungs.)

A middling man eats and drinks in twenty-four hours, about four pounds ten ounces. The plant imbibed and perſpired in the ſame time twenty-two ounces. But taking bulk for bulk, the plant imbibes ſeventeen times more food than the man. For deducting five ounces for fæces, there will remain but four pounds, five ounces, which enter the veins, and paſs off in twenty-four hours. And ſince taking bulk for bulk, the plant imbibes ſo much more food than the man, it was neceſſary by giving it an extenſive ſurface, to provide for a plentiful perſpiration, ſince it has no other way of diſcharging ſuperfluities as a man has. It was neceſſary likewiſe that the plant ſhould imbibe a larger quantity of freſh fluid than the man, becauſe the fluid filtrated through its roots does not contain ſo many nutritive particles, as the chyle which enters our veins.

But there is a latitude of perſpiration both in men and plants. In this flower it varied from ſixteen to eighteen ounces during twelve hours a day, as it was watered leſs or more: in a healthy man it varies from a pound and a half to three pounds.

Ever-greens perſpire far leſs than other plants. In proportion, they need leſs nouriſhment: hereby they are better able to bear the winter: like inſects, which

as

as they perſpire little, live the whole winter without food.

In order to try whether any ſap roſe in winter, he made various experiments: from all which it appeared, it does riſe then alſo, but in ſmall quantities. And hence we ſee why an ever-green grafted on an oak will remain verdant, when the oak-leaves drop. Perſpiring leſs, it needs leſs nouriſhment than the oak, and ſo is ſufficiently fed by the ſap that riſes even in winter.

In ſummer, when hot ſun-ſhine follows a ſhower, the vines in the middle of a hop-ground, are often all ſcorched up, almoſt from one end of a large ground to the other: at the ſame time the vapours aſcend plentifully. The ſcorching of the vines ſeems to be cauſed by theſe ſcorching vapours, which aſcend moſt in the middle of the ground, the air there being more denſe, and conſequently hotter than on the outſides.

The white clouds likewiſe which appear in ſummer-time, occaſion a vehement heat, by reflecting many of the ſolar rays, which otherwiſe would not touch the earth. And if the ſun be on one ſide, and the clouds on the other, they are perfect burning-glaſſes.

Sometimes there is a kind of hollow clouds, full of hail or ſnow. During the continuance of theſe the heat is extreme, ſince by ſuch condenſation they reflect more ſtrongly. By theſe likewiſe thoſe blaſts may be produced, as well as by the reflection of denſe vapours.

The ſun-flower being tender, if the ſun riſes clear, faces to the eaſt. The ſun continuing to ſhine, at noon it faces to the ſouth, and at ſix in the evening to the weſt. The cauſe is, that ſide of the ſtem which is next the ſun, perſpires the moſt, and thereby ſhrinks.

"What degree of heat will plants bear?" The common temperate point in the thermometer is eighteen degrees. The external heat of a human body, will raiſe it to fifty-four degrees. Very hot ſun-ſhine will raiſe it to eighty-eight. Plants endure a conſiderably greater heat than this, near the line, for ſome hours a day. But the hanging of the leaves of many of them ſhews, they could not long ſubſiſt under it.

The winter heat is from the freezing point to ten degrees; the vernal and autumnal from ten to twenty. The May and June heat is from ſeventeen to thirty, in which the

the generality of plants flouriſh beſt. The heat of July is, in the ſhade, about thirty-eight degrees; in the ſun-ſhine, at noon, about fifty. The heat of a hot-bed, when too hot for plants, is eighty-five or more: and near this is the heat of the blood in high fevers. The due heat of a hot-bed is fifty-ſix degrees; and the ſame heat hatches eggs.

A continual ſteam is aſcending during the ſummer: the ſun-beams giving the moiſture of the earth, at two feet depth, a briſk, undulating motion, which rarefied by heat, aſcends in the form of vapours. And the vigour of warm and confined vapour (ſuch as is that which is two or three feet deep in the earth) muſt be great, and penetrate the roots with ſome vigour; as we may reaſonably ſuppoſe, from the vaſt force of confined vapour in the engine for raiſing water by fire.

Though vegetables have not, like animals, an engine which by its alternate dilatations and contractions, drives their juices through them, yet has nature contrived other means, powerfully to raiſe the ſap and keep it in motion. And their roots are covered with a very fine thick ſtrainer, that nothing may enter but what can be readily carried off by perſpiration.

That there is a lateral communication of the ſap-veſſels in plants, as of the blood-veſſels in animals, plainly appears from the experiment of inarching trees. For when three wall-trees are thus incorporated, the root of the middlemoſt may be dug up, and the tree will grow ſtill, as receiving nouriſhment from the trees with which it is connected. And hence elders, willows, vines and moſt ſhrubs, will grow with their tops downward in the earth. For the ſame reaſon, if you frequently, in an evening, waſh the bodies of new-planted trees, they will grow quicker and better than any others of the ſame plantation.

22. If the top of a viburnum is planted in the ground, it becomes roots, and the roots turned up become branches; and the plant grows exactly as well as it did in its natural poſition; whether the veſſels which fed the branches have changed their courſe, or whether the juices go up and down the ſame veſſels.

23. I cannot

23. I cannot better conclude this chapter, than by tracing the analogy between the propagation of animals and that of vegetables. The roes of fiſhes, the eggs of inſects, birds, and all other animals nearly reſemble each other. They are compact bodies of ſuch forms as beſt ſuit their natures. They all have integuments nobly contrived for their preſervation, with firm coverings to ſecure them from outward injuries. Thoſe to be kept in the body have coverings alſo; but ſoft and membranous. Every kind contains its peculiar ſubſtance, differing from that of every other kind. And all theſe characters belong alſo to ſeeds of every kind. They have their coverings, more or leſs compact, according to their neceſſities. Their forms are convenient. The ſubſtances they contain are ſpecifically different from each other: and their offſpring proceeds from them in the ſame manner, as animals proceed from their eggs.

But beſide the ſubſtances peculiar to each ſeed, there is a peculiar organization treaſured up in each, which is the rudiment of the future plant, capable of being propagated into ſuch a plant as it ſprung from, and no other. So in every one of the nut-kind, there is a viſible organization, peculiar to each ſpecies. And if ſuch an organization appear in every ſeed, which is large enough to be viewed clearly, we cannot reaſonably doubt of their exiſtence, even in thoſe which are ſo ſmall as to eſcape our ſight. There are multitudes of ſeeds, which produce large plants, and yet appear only like duſt, and a vaſt number, which we cannot ſee, but by the microſcope. And yet theſe doubtleſs have all their peculiar forms, and their organizations as well as the larger.

But from what are theſe organizations produced? How does every plant or animal, bring forth a freſh one after its kind? A little of this we may underſtand, if we trace a tree and an animal through every ſtage from the egg to their utmoſt growth.

See a young tree puſhing out its leaves and flowers, till it has extruded an entire ſet of boughs and branches. One part regularly opens after another from the firſt ſhoot till it comes to perfection. Then, and not before, it produces ſeeds, containing the rudiments of

other

other trees like itſelf. The fibres of its general organization grow into little knots, ſome to form leaves, ſome the calix, ſome the petals, ſome the piſtil and utricle, ſome again the little ſeeds, each growing from its own pedicle. For the male parts, other fibres are formed into ſtamina, and from theſe terminate into apices: and again from theſe others terminate into the minute grains, commonly called the farina fæcundans; each grain growing on its own pedicle, juſt as the leaves or fruits of trees.

See an animal, exactly in the ſame manner, unfolding itſelf by degrees, till its parts are explicated entirely, and it is complete in every organ. Then, and not before, each female is capable of producing eggs, each being a continuation of the general organization, and growing upon its own pedicle. Each male likewiſe, when at its ſtate of perfection, is capable of producing from itſelf the fæcundating matter, neceſſary for the propagation of the ſpecies.

Let us again view a full grown tree or plant, putting forth its parts for fructification. Obſerve the apices on the ſtamina, loaded with the globules of the farina fæcundans, the pulp of each globule containing an exalted fluid, and conveying it to one of the papillæ of the piſtil. The utricle is now filled with green, ſoft ſeeds, ready to be impregnated by the globule, and containing a fluid, which afterward becomes a hard covering to each. And within this the little organization gradually increaſes.

As then a refined fluid from the ſeminal matter of the male, impregnates the organization in the egg of a female animal, mingles with the ſubtile fluids contained therein, and promote its growth and progreſs: ſo the refined part of the pulpy fluid contained in the globule, impregnates the organization in the ſeed of a plant, mixes with its juices, and gradually promotes its growth into a perfect plant. And doubtleſs both the impregnating effluvia of animals and vegetables, and the innate juices of the organization, have qualities peculiar to themſelves. Hence the offſpring of a black and white parent, is of a colour between both. And thus if the farina of one ſort of flower impregnate the

egg

egg of another, the colour of the flower produced thereby is variegated proportionably.

The juices imbibed by a plant, being compoſed of innumerable various ſubſtances, after every part has attracted its kindred particles, the ſuperfluous ones are carried off by perſpiration: chiefly by the leaves, which are the emunctories, that throw off thoſe juices which have no kindred particles in the plant. Accordingly when the warm ſun begins to rarefy the fluids, which during the winter were condenſed and inactive, the new leaves then begin to put forth, from their ſeveral organizations. When winter comes, as no more fluids aſcend in trees, ſo there is no perſpiration. Conſequently moſt of them need leave no longer, which therefore fall off. Nor are they ſucceeded by others, till the vegetable begins to receive freſh nouriſhment, and has occaſion therefore for excretory veſſels to carry off ſuperfluities. Juſt ſo the ſuperfluous juices in animals, are continually carried off by perſpiration: an obſtruction of which is equally pernicious to animals and vegetables.

But is there any thing in the vegetable kingdom analogous to that ſtrange animal the polypus, which multiplies by being cut in pieces? There is. View, for inſtance a young willow. This is an organized body, capable of growing, till it comes to its perfect growth by means of the vegetative principle. The polypus is an organized body, capable of being extended till it comes to its perfect growth, and of feeding and loco-motion, by its animating principle. The willow as it grows, is gradually ſending off new branches, which are its fætuſes, proceeding from the organizations lodged in every part. The polypus in like manner gradually ſends off new fætuſes; from organizations placed in every part of it. If the willow be cut in pieces and planted, each piece will be explicated into a tree, and then ſend forth new fætuſes, like its parent. And if the polypus be cut in pieces, each piece will be explicated into a polypus, and then extrude new fætuſes: ſo that cutting it in pieces, is but anticipating the propagation of thoſe organizations in the pieces, which would, if let alone for awhile, themſelves iſſue from the ſides of the parent.

If we obſerve the extreme tenderneſs of this animal, liable to be wounded, nay torn in pieces, by any hard body, which is carried down the ſtreams, or moved in the ponds, wherein they dwell: we ſee the providential reaſon, for this contrivance to propagate them: as perhaps no other animal is of ſo tender a texture, and ſo eaſily deſtroyed, having neither ſagacity to avoid danger, nor ſtrength to bear the leaſt violence.

Other trees have been propagated by a ſtill more ſurpriſing way. One having cauſed ſome aſhen pipes, that had brought water to his fountain twelve years to be taken up, they were left in the yard, where they rotted almoſt entirely. But in their room there ſhot up a young foreſt of aſhes, which are now about four feet high. There is no aſh-tree within a great diſtance of the yard. Where then were the ſeeds from which they ſprung?

24. Mr. Bonet of Geneva was inclined to try whether plants would grow, when planted in moſs inſtead of earth. So he filled ſeveral garden-pots with moſs, and compreſſed it more or leſs, as he judged the ſeveral plants might require, a cloſer or a looſer ſoil.

He then ſowed therein wheat, barley, oats, and peas. And he found firſt, that all the grains thus ſown, came to maturity later than thoſe of the ſame ſorts, which had been ſown in mould. 2. That the ſtems from the ſeeds ſown in moſs, were generally taller than thoſe ſown in earth. 3. That there came more blades from the grains ſown in moſs, than from thoſe ſown in the ground. 4. The grains ſown in moſs produced more plentifully than the others. 5. The grains gathered from the corn which grew in the moſs, having been ſown again partly in moſs, and partly in earth, ſucceeded well in both.

He alſo planted in moſs, pinks, daiſies, tulips, jonquilles, and ſeveral other ſorts of flowers. And all theſe ſucceeded full as well, as thoſe of the ſame ſort which he planted in mould. He alſo placed in moſs, cuttings and layers of vines, all which grew up into vines. And theſe in awhile were larger than thoſe which came from cuttings and layers planted at the ſame time in the ground.

Mr. Kraft ſowed oats and hemp-ſeed in rich earth,

in

in ſand thoroughly dried, in ſhreds of paper, in pieces of woollen cloth, in chopt hay. He afterwards watered them daily, and they grew near as well in one ſubſtance as in another.

The huſbandry of figs, as it is ſtill practiſed in many parts, is one of the greateſt curioſities in nature. There are two ſorts of fig-trees, the wild and the garden fig-tree. The wild bear three kinds of fruit, fornites, cratitires, and orni: and all theſe are neceſſary to ripen the garden-fig. The fornites appear in Auguſt, and hold to November without ripening. Herein breed ſmall worms, which turn to a kind of gnats, no where to be ſeen but about theſe trees. In November theſe gnats make a puncture in the cratitires, which do not appear till towards the end of September, and the fornites gradually fall off, after the gnats have left them. The cratitires remain on the tree till May, and encloſe the eggs depoſited in them. In May the orni appear, which after they grow to a certain ſize, are pricked by the gnat iſſuing from the cratitires.

None of theſe are good to eat, but only to ripen the fruit of the garden fig-tree in the following manner. In June and July, the peaſants take the orni, when their gnats are juſt ready to break out, and carry them to the garden fig-tree. If they do not mind the time exactly, the orni drop and the garden fruit not ripening for want of its proper puncture, will likewiſe fall ſoon after. Therefore they carefully inſpect the orni every morning, and transfer ſuch of them as are proper. By this means the garden-figs become ripe, in about ſix weeks after they have received the puncture of the inſect. When they have dried them in the ſun, they put them into ovens, to deſtroy the eggs of the gnats laid in them, from whence otherwiſe worms would be produced, which would conſume the fruit.

What an expenſe of time and pains is here! Who can but admire the patience of the Greeks, buſied above two months in carrying theſe prickers from one tree to another! But how do theſe contribute to the ripening of the garden-figs? Perhaps by cauſing the nutritious juice to extravaſate, whoſe veſſels they tear aſunder, in depoſiting their eggs. Perhaps too they leave with their eggs ſome kind of liquor, proper to ferment with the milk of the fig, and make it tender.

Figs in Paris ripen ſooner, for having their buds pricked with a ſtraw dipped in oil.

CHAP. II.

1. *Of ſome particular plants.*
2. *Sugar not unwholeſome.*
3. *Maple Sugar.*
4. *Molaſſes from Apples.*
5. *Of Ambergris.*
6. *Of the corruption of plants and animals.*
7. *General Reflections.*
8. *Eſſay on the production, &c. of plants and animals.*

1. IT remains to give a ſhort account of ſome remarkable productions of the vegetable kind.

The graſs of the ſubmarine meadows is not a ſpan long, and is of a green approaching to a yellow colour. The tortoiſes ſeem to live wholly on this: but they bite much more of it than they ſwallow. Hence the ſea is covered with this graſs, wherever they feed at the bottom. About once in half an hour they come up, fetch one breath like a ſigh, and ſink again. They breathe ſomewhat oftner when on ſhore; if you hurt them, the tears will trickle from their eyes. They will live out of water twenty days and be fat, if they have twice a day half a pint of ſalt-water.

A ſubmarine ſenſitive plant has been obſerved on the Iriſh coaſt. It conſiſts of a long ſlender tube about as thick as the barrel of a gooſe quill, growing about ſix or eight inches out of the crevices of the rocks, eſpecially in ſuch hollows as the ſalt-water remains in, after the tide ebbs away. In the middle of the tube ſprings up a ſlender ſtalk. The top of which is a reddiſh, round veſicle. If you point a finger to this, as ſoon as you are near touching it, the ſtalk withdraws to the very bottom of the tube, and the tube itſelf bends

and

and becomes flaccid. The plant has no branches, nor can the root be ſeparated from the rock without breaking it. On the Corniſh ſhores, there grows a kind of a ſenſitive fucus. Bring this ſo near the fire as juſt to warm, and its edges ſhrink up. In this ſtate, move a finger toward them, and they ſhrink from it, but if the finger is removed, recover their former ſituation. Placed on a warm hand, it moves perpetually to and from the hand, like an animal ſtruggling for life. It ſeems this odd effect is owing to the ſtructure of theſe plants. They are ſo extremely thin that they yield to the perſpiration of the hand; the effluvia being of force ſufficient to repel the leaves when they are near.

The vines of hops wind about the poles with the ſun, thoſe of kidney-beans againſt the ſun, and that ſo obſtinately, that although the one or the other be overnight wound the oppoſite way, yet in the morning it will be found to be got back again to its natural bent.

The herb of Paraguay, as it is called, is the leaf of a tree, of the ſize of a middling apple-tree. It is ſent to Peru and Spain, in great quantities, well dried and almoſt reduced to powder, being uſed by the miners and many others, as we uſe wine, and the Turks opium to raiſe the ſpirits. Indeed the Spaniards believe it to be a preſervation from, and remedy for all their diſorders. It is opening and diuretic, and what is ſurpriſing, produces very different effects at different times. It purges ſome, and nouriſhes others: it gives ſleep to the reſtleſs and ſpirits to the drowſy. Thoſe who are accuſtomed to the uſe of this herb, can ſcarce ever leave it off, or even take it moderately; though when uſed to exceſs, it brings on moſt of thoſe diſorders that attend the too free uſe of ſtrong liquors. They prepare it nearly as we do tea; but ſeldom uſe any ſugar with it. Sometimes they take it by way of a vomit: then they drink it lukewarm.

The caa-tree (that is its proper name) thrives beſt in the marſhy bottoms between the mountains of Maracayu, eaſt of Paraguay, in about twenty-five degrees twenty-five minutes ſouth latitude. They ſometimes ſend to Peru alone in a year, a hundred thouſand

arobes, (an arobe is 28 pounds,) and each arobe is worth ſeven French crowns.

By the whole account, this appears to be a ſpecies of tea, little differing from ſome of thoſe which grow in China. The leaf is a third part leſs than that of bohea-tea, but much hardier: for it bears the Engliſh froſt, which that will not. Bohea-tea has a ſmaller and a darker leaf than green; which is as large and as bright as a bay-leaf, and endures all weathers. All theſe appear to be of a laurel kind, and I doubt, if laurel or bay leaves properly cured, would not equal any of them.

The coco-tree grows ſtrait, without any branches, thirty or forty feet high. Near the top it bears twelve leaves, each ten feet long, and half a foot broad. Theſe are uſed in making mats, covering houſes, and for many other purpoſes. Above the leaves grows a large excreſcence, in the form of a cabbage. But the taking it off kills the tree. Between the leaves and the top grow ſeveral ſhoots, as thick as a man's arm, which when cut, yield a white, ſweet, agreeable liquor, ſerving as wine, and equally intoxicating. Yet at the end of four and twenty hours, it becomes a ſtrong vinegar. As long as this liquor diſtils, the tree bears no fruit: but when theſe ſhoots are ſuffered to grow, it puts forth a large bunch, wherein the coco-nuts are to the number of ten or twelve. In each there is about half a pint of clear, cooling water. In a little while this becomes a white, ſoft pulp, which afterwards condenſes into a nut. The tree yields fruit thrice a year. Some of the nuts are as large as a man's head.

The cacao tree is of a middling ſize: the wood is porous, the bark is ſmooth, and of a cinnamon colour. The flower grows in bunches between the ſtalks and the wood, of the form of roſes, but without ſcent. The fruit containing the cacao is a ſort of pod, of the ſize and ſhape of a cucumber. Within this is a pleaſant, acid pulp, which fills up the interſtices of the nuts till they are ripe. Then they lie cloſe together, in a regular and elegant order. They have a tough ſhell; within which is the oily ſubſtance, whereof the chocolate is made. This fruit grows differently from our

European

European fruits, which always hang upon the ſmall branches: whereas this grows along the body of the great ones, principally at the joints. None are found on the ſmall; a manner of vegetation ſtrange here; but which prevails in ſeveral other plants within the tropics.

The tallow-tree, which grows plentifully in China, is about the height of a cherry-tree. Its bark is very ſmooth, and its leaves of a deep ſhining red. Its fruit grows in a pod, like a cheſnut, conſiſting of three white grains: each of which is about the ſize, and of the form of a ſmall nut. In each is a little ſtone, ſurrounded with a white pulp, in conſiſtence, colour, and even ſmell, like tallow. And this it is, of which the Chineſe in general make their candles.

The horſe cheſnut contains a ſaponaceous juice, uſeful not only in bleaching, but alſo in waſhing linens and ſtuffs. Peel and grind them; then the meal of twenty-nuts, is ſufficient for ten or twenty quarts of water. Either linen or woollen may be waſhed in the infuſion, without any other ſoap. It takes out ſpots of all kinds, rinſing the clothes afterwards in ſpring water.

If you grind the nut, ſteep the meal in hot water, and then mix it with an equal quantity of bran, both hogs and poultry will eat it. Both horſes and cows will eat the nut itſelf, mixt with other food.

The ſago-tree is between 20 and 30 feet high, and about 5 or ſix round. It grows in the Molucca iſlands. Its outward bark is about an inch thick: under this are ligneous fibres, which cover a maſs of a kind of gummy meal. When this is ripe, a whitiſh duſt tranſpires through the leaves. The Malais then cut down the tree, ſcoop out the mealy ſubſtance, dilate it with water, and ſtrain it through a fine cloth. It afterwards gradually dries and hardens, and will keep good for many years.

Palm-trees are male and female. In March or April, when the ſheaths that encloſe the young cluſters of the flowers and fruit begin to open, (at which

arobes, (an arobe is 28 pounds,) and each arobe is worth ſeven French crowns.

By the whole account, this appears to be a ſpecies of tea, little differing from ſome of thoſe which grow in China. The leaf is a third part leſs than that of bohea-tea, but much hardier: for it bears the Engliſh froſt, which that will not. Bohea-tea has a ſmaller and a darker leaf than green; which is as large and as bright as a bay-leaf, and endures all weathers. All theſe appear to be of a laurel kind, and I doubt, if laurel or bay leaves properly cured, would not equal any of them.

The coco-tree grows ſtrait, without any branches, thirty or forty feet high. Near the top it bears twelve leaves, each ten feet long, and half a foot broad. Theſe are uſed in making mats, covering houſes, and for many other purpoſes. Above the leaves grows a large excreſcence, in the form of a cabbage. But the taking it off kills the tree. Between the leaves and the top grow ſeveral ſhoots, as thick as a man's arm, which when cut, yield a white, ſweet, agreeable liquor, ſerving as wine, and equally intoxicating. Yet at the end of four and twenty hours, it becomes a ſtrong vinegar. As long as this liquor diſtils, the tree bears no fruit: but when theſe ſhoots are ſuffered to grow, it puts forth a large bunch, wherein the coco-nuts are to the number of ten or twelve. In each there is about half a pint of clear, cooling water. In a little while this becomes a white, ſoft pulp, which afterwards condenſes into a nut. The tree yields fruit thrice a year. Some of the nuts are as large as a man's head.

The cacao tree is of a middling ſize: the wood is porous, the bark is ſmooth, and of a cinnamon colour. The flower grows in bunches between the ſtalks and the wood, of the form of roſes, but without ſcent. The fruit containing the cacao is a ſort of pod, of the ſize and ſhape of a cucumber. Within this is a pleaſant, acid pulp, which fills up the interſtices of the nuts till they are ripe. Then they lie cloſe together, in a regular and elegant order. They have a tough ſhell; within which is the oily ſubſtance, whereof the chocolate is made. This fruit grows differently from our

European

European-fruits, which always hang upon the ſmall branches: whereas this grows along the body of the great ones, principally at the joints. None are found on the ſmall; a manner of vegetation ſtrange here; but which prevails in ſeveral other plants within the tropics.

The tallow-tree, which grows plentifully in China, is about the height of a cherry-tree. Its bark is very ſmooth, and its leaves of a deep ſhining red. Its fruit grows in a pod, like a cheſnut, conſiſting of three white grains: each of which is about the ſize, and of the form of a ſmall nut. In each is a little ſtone, ſurrounded with a white pulp, in conſiſtence, colour, and even ſmell, like tallow. And this it is, of which the Chineſe in general make their candles.

The horſe cheſnut contains a ſaponaceous juice, uſeful not only in bleaching, but alſo in waſhing linens and ſtuffs. Peel and grind them; then the meal of twenty-nuts, is ſufficient for ten or twenty quarts of water. Either linen or woollen may be waſhed in the infuſion, without any other ſoap. It takes out ſpots of all kinds, rinſing the clothes afterwards in ſpring water.

If you grind the nut, ſteep the meal in hot water, and then mix it with an equal quantity of bran, both hogs and poultry will eat it. Both horſes and cows will eat the nut itſelf, mixt with other food.

The ſago-tree is between 20 and 30 feet high, and about 5 or ſix round. It grows in the Molucca iſlands. Its outward bark is about an inch thick: under this are ligneous fibres, which cover a maſs of a kind of gummy meal. When this is ripe, a whitiſh duſt tranſpires through the leaves. The Malais then cut down the tree, ſcoop out the mealy ſubſtance, dilate it with water, and ſtrain it through a fine cloth. It afterwards gradually dries and hardens, and will keep good for many years.

Palm-trees are male and female. In March or April, when the ſheaths that encloſe the young cluſters of the flowers and fruit begin to open, (at which

time

time the dates are formed) they take a ſprig of the male cluſter, and inſert it into the ſheath of the female; or elſe take a whole cluſter of the male tree, and ſprinkle the farina of it over ſeveral cluſters of the female. Where they uſe the former method, one male ſuffices to impregnate four or five hundred females.

The palm-tree is in its greateſt vigour about thirty years after tranſplantation, and for ſeventy years longer bears yearly fifteen or twenty cluſters of dates, each of fifteen or twenty pounds weight. Afterward they gradually pine away, and uſually fall about the latter end of their ſecond century.

To procure the honey of the palm-tree, they cut off its head, and ſcoop the top of the trunk into the ſhape of a baſon. The ſap aſcending lodges in this cavity, for the firſt ten or twelve days, three quarts or a gallon a day. Then it gradually diminiſhes, till in ſix or eight weeks, the juices are conſumed, and the tree is fit only for firewood. This liquor is a thin ſirup, of a more luſcious ſweetneſs than honey. Hence our Poet mentions,

> " Fruit of palm-tree, pleaſant to our thirſt
> And hunger both :"

Though one would imagine, a liquor of that kind, would not be very proper to quench thirſt.

I find of the number of Sicilian plants, ſays a late writer, the cinnamon, ſarſaparilla, ſaſſafras, rhubarb, and many others commonly thought not to be natives of Europe. The palma Chriſti too, that plant ſo much celebrated of late, from the ſeed of which the caſtor oil is made, grows in many places of Sicily in the greateſt abundance. Our botaniſts have called it Ricinus Americanus, ſuppoſing it only to be produced in that part of the world.

But the moſt uncommon of all the vegetable productions of Sicily, are ſome of the trees that grow on the ſides of Mount Ætna. Three of theſe are nearly of one ſize; but one is rather taller than the other two. It riſes from one ſolid ſtem to a conſiderable height; after which it branches out. I meaſured it about two feet from the ground, and found it ſeventy-ſix feet round.

round. All theſe grow on a thick, rich ſoil, formed originally of aſhes thrown out by the mountain.

The balſam tree grows on rocks, and frequently on the limbs or trunks of other trees. This is occaſioned by birds ſcattering or voiding the ſeeds, which being glutinous, like thoſe of miſtletoe, take root and grow: but not finding ſufficient nouriſhment, the roots ſpread on the bark till they find a decayed hole wherein is ſome ſoil. Into this they enter and become a tree. But the nouriſhment of this ſecond ſpot being exhauſted, one or two of the roots paſs out of the hole, and fall directly to the ground, though at forty feet diſtance. Here again they take root, and become a much larger tree than before. They flouriſh on the Bahama Iſlands, and many other of the hot parts of America.

In Italy are many coppice woods, of what our gardeners call the flowering aſh. Manna is procured by piercing the bark, and catching the ſap, as we do that of birch trees, to make birch wine. It begins to run in the beginning of Auguſt, and in a dry ſeaſon, runs for five or ſix weeks. But we have no need to be beholden to the king of Naples; for the tree grows as well in England as in Italy. What ſtupidity is it then, to import, at a large expenſe, what we may have at our own doors? The leaves of this tree are the proper ſena, and better than any brought from Apulia.

Peruvian bark comes from a tree, about the bigneſs of a plumb-tree. Its leaves are like ivy, and are always green. It is gathered in autumn, the rind is taken off all round, both from the boughs and the tree, and grows again in four months. It bears a fruit, not unlike a cheſnut, except its outward ſhell. This ſhell is properly called China-China, and is eſteemed by the natives, far above the bark, which is taken from the trunk or boughs. And it ſeems this only was in uſe, till the demand for it ſo increaſed.

The tree which produces cotton is common in ſeveral parts both of the Eaſt and Weſt Indies. The fruit is oval, about the ſize of a nut. As it ripens, the outſide

outſide grows black, till opening in ſeveral places by the heat of the ſun, it diſcovers the cotton, of an admirable whiteneſs. But as fine cotton is now made in Ireland from flax, as ever grew on the cotton-tree.

Pepper grows on a ſhrub in ſeveral parts of the Eaſt Indies, which is of the reptile kind; and for that reaſon is uſually planted at the foot of ſome larger tree. It grows in cluſters, which at firſt are green. As the grains ripen, they grow reddiſh; and after being expoſed awhile to the ſun, become black. To make white pepper, they moiſten it with ſea-water, and then expoſing it to the ſun, diveſt the grains of the outer bark, which of conſequence leaves them white.

The tree that bears Jamaica pepper, is about thirty feet high, and covered with a grey, ſmooth, ſhining bark. It ſhoots out abundance of branches, which bear large leaves, like thoſe of the bay-tree. At the very end of the twiggs grow bunches of flowers, each ſtalk bearing a flower which bends back. To theſe ſucceeds a bunch of berries, larger when ripe than juniper-berries. They are then black, ſmooth, and ſhining; but they are taken from the tree when unripe, and dried in the ſun. They have a mixed flavour of many kinds of ſpice, and hence they are called allſpice.

The plant which affords ginger, reſembles our reed, both in its ſtem and leaves. The root ſpreads itſelf near the ſurface of the ground, in form not unlike a man's hand. When it is ripe they dig it up, and dry it either in the ſun, or in an oven.

Nutmegs are encloſed in four different covers: the firſt, thick and fleſhy, like that of our walnuts: the ſecond is a thin, reddiſh coat, of an agreeable ſmell, called mace. The third is a hard blackiſh ſhell. The fourth is a greeniſh film. In this the nutmeg, is found, which is properly the kernel of the fruit.

The wild-pine, as it is called, is a wonderful inſtance of the wiſe providence of God. The leaves of it are channelled, to catch and convey water into their reſervoirs.

reſervoirs. Theſe reſervoirs are ſo made, as to contain much water. And they cloſe at the top when they are full, to hinder its evaporation. Theſe plants grow on the arms of the trees in the woods, as alſo on the bark of their trunks. Another contrivance of nature in this vegetable is very admirable. The ſeed has many long and fine threads, that it may be carried every where by the wind, and that by theſe, when driven through the boughs, it may be held faſt, and ſtick to the arms or trunks of trees. As ſoon as it ſprouts, although it be on the under part of a bough, its leaves and ſtalk riſe perpendicular, becauſe if it had any other poſition, the ciſtern made of hollow leaves could not hold water. In ſcarcity of water, this reſervoir is not only neceſſary and ſufficient for the plant itſelf, but likewiſe uſeful to men, birds and inſects. Hither they then come in troops, and ſeldom go away without refreſhment.

Theſe leaves will hold a pint and a half, or a quart of rain-water. When we find theſe pines, ſays Captain Dampier, we ſtick our knives into the leaves, juſt above the root; and that lets out the water, which we catch in our hats, to our great relief.

The ſame providential deſign is anſwered by the water-withy of Jamaica. This, which is a kind of vine, grows on dry hills in the woods, where no water is to be found. Its trunk, if cut into pieces, two or three yards long, and held by either end to the mouth, affords a limpid, innocent and refreſhing ſap, as clear as water: and that in ſo great abundance, as gives new life to the weary and thirſty traveller.

An admirable inſtance of the ſame good providence we have in the fountain tree, which grows on Hierro, one of the Canary Iſlands. In the rocky cliff which ſurrounds the iſland, is a narrow gutter, which begins at the ſea, and continues to the ſummit of the cliff, where it falls into a valley, which is bounded by the ſteep front of a rock. On the top of this grows a tree, which has continued many years. Its leaves conſtantly diſtil as much water as is ſufficient for the drink of every living creature on the iſland. It ſtands by itſelf a league and a half from the ſea, and no one

knows of what ſpecies it is. Its trunk is about nine feet round, its diameter about three. It is thirty feet high; the circumference of all the branches together is about ninety. The branches are thick, the loweſt of them is about an ell from the ground. Its fruit reſembles an acorn, its leaves reſemble thoſe of the laurel, but are longer and broader. They come forth in perpetual ſucceſſion, ſo that the tree is always green. On the north ſide of it are two ciſterns of rough ſtone, each fifteen feet ſquare, and twelve deep: one of which contains water for the drink of the inhabitants, the other, for their cattle and all other purpoſes.

Every morning, near this part of the iſland, a miſt riſes from the ſea. This the ſouth and eaſterly winds drive againſt the forementioned cliff, which it gradually aſcends, and thence advances to the end of the valley. Being ſtopped there by the front of the rock, it reſts upon the leaves and branches of the tree, whence it diſtils the remainder of the day.

But trees yielding water are not peculiar to the iſland of Hierro. One of the ſame kind grows on the Iſland of St. Thomas, in the gulf of Guinea. And of the ſame nature is that near the mountains of Vera Pogz, whereof we have the following account in Cockburne's Voyages.

"In the morning of the fourth day, we came out on a large plain, in the midſt of which ſtood a tree of an unuſual ſize. Its trunk was above five fathoms round; the ſoil it grew on was very ſtony. And on the niceſt inquiry we could afterwards make, both of the Spaniards and the natives, we could not learn, that any other ſuch tree had been known in all New Spain.

"Perceiving the ground under it wet, we were ſurpriſed, knowing that according to the certain courſe of the ſeaſon in that latitude, there had no rain fallen for ſix months, and that it could not be owing to the dew, for this the ſun entirely dried up, in a few minutes after its riſing. At laſt, to our great amazement, as well as joy, we perceived water dropping from the end of every leaf; after we had been labouring four days through extreme heat, and were almoſt expiring for thirſt, we could not look upon this, but as liquor ſent from Heaven, to relieve us in our extremity. We

catched

catched it in our hands, and drank ſo plentifully, that we could ſcarce tell when to give over."

The manchineel apple is moſt beautiful to the eye, agreeable to the ſmell, and pleaſant to the taſte, but the whole tree is ſo poiſonous, that the wood of it while green, if rubbed againſt the hand, will raiſe bliſters.

The wood is good for tables, cabinets, and all other curious work. But the virulent nature of the ſap, calls for great caution in felling the tree. I was cutting down one of them, ſays Mr. Cateſby, when ſome of the milky juice ſpurting in my eyes, I was two days totally blind, my eyes and face being much ſwelled. For four and twenty hours, I felt a violent pricking pain, which then gradually abated.

Indeed it is reported, and generally believed of this tree, that the wound of an arrow dipped in its juice is mortal, that the rain which waſhes the leaves, will raiſe bliſters on the ſkin; and that even its ſhadow is ſo noxious, that the bodies of theſe that ſleep under it ſwell. Yet a pregnant woman ate three of the apples without any inconvenience; and a robuſt man of about forty-five years of age, ate more than two dozen without being diſordered more than twenty-four hours. About an hour after he had eaten them, his belly ſwelled, and he complained of a burning heat in his bowels. He could not keep his body in an erect poſture: his lips were ulcerated, and he was ſeized with cold ſweats; but he was relieved from all theſe ſymptoms by a decoction of the leaves of ricinus, the avellana purgatrix, in water, which being drank plentifully, produced a violent vomiting and purging, for four hours, after this he was made to walk about, and ſome rice gruel perfected the cure.

The negroes in Africa uſe a poiſon of an extraordinary nature. The doſe is very ſmall, and hath no ill taſte. The ſymptoms are various, according as the doſe is. It kills ſometimes in a few hours, ſometimes in months; at others, in ſome years. If a great quantity is given, death follows in ſix or ſeven hours. (The negroes turn white.) If the doſe is but ſmall, the ſick loſes his appetite, feels pain in his head, arms and limbs, a wearineſs all over, ſoreneſs in his breaſt, difficulty in breathing, and at laſt dies languiſhing. Probably it is

the

the ſame poiſon which is uſed in Spain and Italy. This hath but one ſpecific antidote, the knowledge of which a famous negroe-priſoner, was at length perſuaded to impart. The antidote is the root of the ſenſitive plant. Take none of the root but what is in the ground; waſh it well, and ſplit it in two. Take a good handful of theſe ſplit roots; ſteep them in three quarts of fair water, in an earthen glazed pot, having a cover. Uſe but a moderate fire, that it may boil gently. The decoction has no ill taſte; you may add ſugar, as you think beſt. Give the patient a good glaſs of this decoction as warm as he can drink it; an hour after give another, and ſo for ſome time, till you make a perfect cure. There is no danger of giving too much, it can do no harm at all.

In the valley of the Lancy, which runs between the mountains of Juria, grows a plant like the doronicum, near the roots whereof is found pure quick-ſilver, running in ſmall grains like pearls. One would not imagine the plant had any influence on this, but for the following experiment. Expreſs the juice: expoſe it to the air in a clear night, and there will be found as much mercury as there is loſt of juice.

But of all productions of the vegetable kind, there is none more remarkable than the aloe. It grows exceeding ſlowly. But the ſlowneſs of its growth is afterwards compenſated by the bulk to which it arrives, the velocity with which it ſhoots, and the prodigious number of flowers it produces, which ordinarily amount to ſeveral thouſands. It uſually takes up three months, May, June, and July, from the firſt budding of the ſtem, to the finiſhing of the flowers. There are, however, exceptions to this rule. The aloe in the garden of Cardinal Farneſe, at Rome, ſhot up in the ſpace of one month, to the height of twenty-three feet. Another at Madrid grew ten feet in one night, and twenty-five more in the night following.

The progreſs of the Venetian aloe, in the garden of Signior Papatava, was as follows. It began to ſhoot its ſtem on the 20th of May, which by the 19th of June, was riſen four paduan feet and an inch. On the 24th it had gained ten inches more, and on the 29th eight more,

more, on which day it began to emit branches. On the 6th of July it had gained one foot one inch: on the 17th one foot eight inches more; on the 7th of Auguſt, one foot and a half. From that day to the 30th, it grew very ſlowly, but continued emitting branches and flowers. The trunk was at the bottom a foot thick; the branches were twenty-three in number. On the top of each was a knot or collection of flowers. On each of the firſt branches there were a hundred and twelve: on others a hundred and ten, and on others a hundred. They yielded little ſmell: but what was of it was agreeable.

When the tree has once flowered, it quickly dies, being quite exhauſted by ſo copious a birth. They ſeldom flower till they are of a conſiderable age, when they are of a large ſize and a great height. As ſoon as the flower-ſtem begins to ſhoot from the middle of the plant, it draws all the nouriſhment from the leaves, ſo that as that advances, theſe decay. And when the flowers are fully blown, ſcarce any of the leaves remain alive. But whenever this happens, the old root ſends forth a numerous quantity of offsets for increaſe.

Perhaps there is ſcarce any plant in the creation which is of ſo general uſe. The wood of it is firm, and ſerves for fences, and for the uſe of the carpenter. The leaves make coverings for houſes: the ſtrings and fibres ſerve, in the room of hemp, flax and cotton. Of the prickles are made nails and awls, as alſo pins and needles. And from a large aloe, when rightly tapped, may be drawn three or four hundred barrels of juice, which by diſtillation grows ſweeter and thicker till it becomes ſugar.

If there be a more beautiful flower than that of the aloe, it grows on a ſpecies of cereus (or prickly pear, as they call it, in America) which grows well in our ſtoves: about the middle of July the flower is grown to its bigneſs. Till then it appears like a bit of wool on a dead ſtem. It uſually begins to open about five in the evening, is full blown about eight, and continues ſo till about four the next morning. It then gradually cloſes, and is ſhut up about ſix o'clock, covered with a cold moiſture. The calyx or empalement is a foot diameter, divided into ſixty ſegments; the outſide of a fine gold colour, the inſide of a ſplendid yellow, ſpreading

ing like the rays of a ſtar. The petals are about thirty, in form of a cup, of a pure white. There is one ſtyle ſurrounded by a great number of ſtamina. It ſends forth a very fragrant perfume, like the gum benjamin while in bloſſom; the empalement and petals open one by one with great elaſticity.

There is not in nature any flower of greater beauty, or that makes a more magnificent appearance. What pity, that it is only an ephemeron! literally the creature of a day!

It has been before obſerved, That as all animals are from eggs, ſo all vegetables are from ſeeds. But many have ſuppoſed there is one ſort of vegetable, which is an exception to this: namely muſhrooms, the ſeeds whereof have been long ſought in vain. And it is certain, if you only range in April, balls of horſe dung, as big as one's fiſt, in lines three feet diſtant from each other, and one foot under the ground, covering them all over with mould, and that again with horſe dung, in the beginning of Auguſt the upper pieces of dung will begin to grow white: being covered with fine white threads, woven about the ſtraws whereof the dung is compoſed. By degrees the extremities of theſe threads grow round into a kind of button: which enlarging itſelf by little and little, at length forms itſelf into a muſhroom. At the foot of each, when at its full growth, is an infinity of little ones. The white threads of the dung preſerve themſelves a long time without rotting, if kept dry. And if they are laid again in the ground, they will produce new muſhrooms.

"Are theſe then any thing elſe than the mouldineſs or putrefaction of horſe-dung?" Yes certainly. Indeed all mouldineſs, ſo called, is a congeries of very ſmall plants. And theſe in particular, like other plants, have their origin from ſeeds. But before the ſeeds can vegetate, there are required, certain juices, proper to penetrate their coats, to excite a fermentation in them, and to nouriſh the minute parts thereof. Hence ariſes that vaſt diverſity of places; wherein different ſorts of this plant are produced. Some will only grow on other particular plants, whoſe trunk or roots have the juices proper for them. Nay, there is one ſort which

grows

grows only on the fillets and bandages of the patients in the hoſpital at Paris. It is not therefore at all ſurpriſing that horſe-dung ſhould be a fit ſoil for common muſhrooms. It is probable the ſeeds of theſe are ſpread in numberleſs places, well nigh throughout the whole earth. And the ſame may be ſaid concerning the ſeeds of many plants, as well as the eggs of many inſects: more eſpecially of thoſe which are ſo minute, that we can ſcarce diſcern them even with glaſſes: ſeeing the ſmaller they are, the more eaſily may the leaſt wind convey them hither and thither. So that in truth the earth is full of an inconceivable number both of animals and vegetables, perfectly formed in all their parts, and deſigned as it were in miniature; only waiting for certain favourable circumſtances to enable them to make their appearance at large. How rich then muſt that hand be, which hath ſown them with ſo much profuſion!

It may not be improper before concluding this head, to deſcribe one more ſpecies of ſea-plants. Coral grows chiefly in grottoes, which open to the ſouth, and whoſe concave arch is nearly parallel to the ſurface of the earth. It will not grow at all, but where the ſea is quiet as a pond. It vegetates the contrary way to all other plants; its root adhering to the top of the grotto, and its branches ſhooting downward. The root takes the exact form of the ſolid it grows to, and covers it (as far as it goes) like a plate: and this is a probable proof, that its ſubſtance was originally fluid. Accordingly corals ſometimes line the inſide of a ſhell, which they could not have entered but in a fluid form. All its organiſm, with regard to vegetation, ſeems to conſiſt in its rind, in the little tubes whereof the juice runs to the extremities of the branches. And this juice petrifying both in the cells, that encompaſs the coraline ſubſtance, and in thoſe at the extremity of the branches, whoſe ſubſtance is not yet formed, by this means enlarges the plant to its full dimenſions, both in height and bulk. It is vulgarly believed, that coral is ſoft while in the water. But experiment proves the contrary.

It is obſervable that all ſea-plants, (except the alga) are

are without roots. Nor have they any longitudinal, capillary ſap-veſſels, through which rooted plants draw nouriſhment to every part. But the whole ſubſtance of ſea-plants is compoſed of veſicles, which receive their nouriſhment immediately from the ſurrounding water. Conſequently they can have no circulation of the ſap, having no veſſels to convey it from one end of the plant to the other.

2. Many phyſicians affirm, That ſugar is unwholeſome, and moſt, that it deſtroys the teeth. But how will this agree with the following account? "My grandfather, ſays Dr. Slare, took as much ſugar as his butter ſpread upon bread would receive for his daily breakfaſt. He put ſugar into all his ale and beer, and into all the ſauces he uſed to his meat. At eighty years old he had all his teeth ſtrong and firm (having never had the tooth-ache) and never refuſed the hardeſt cruſt. In his 82d year one of his teeth came out, and in two or three years all the reſt. But others filled up their room, and in a ſhort time he had a new ſet quite round. His hair alſo from very white became dark. He continued in health and ſtrength, and died without any diſeaſe, in his ninety-ninth or hundredth year."

3. It is not only from the canes that ſugar is extracted. In New-England much of it is made from the juice of the upland maple. They firſt make a hole in the tree, within a foot of the ground, ſhelving inward, ſo as to hold about a pint. Then they tap this hole, and by a reed draw off the liquor into a veſſel. A large tree will yield between the beginning of February and the end of April twenty gallons of juice. A gallon in boiling ſixteen hours is reduced to three pints, and yields more than two pounds of ſugar, which our phyſicians prefer to all other for medicinal uſes.

4. Molaſſes likewiſe may be procured without ſugar-canes. This was diſcovered a few years ago, by Mr. Chandler, of Woodſtock, in New-England, an inland town, where the common molaſſes is ſcarce and dear. Ever ſince both he and his neighbours ſupply themſelves with it, out of their own orchards. The apple that produces it, is a ſummer ſweeting, of a middling ſize,

ſize, and full of juice. They grind and preſs the apple, and then gently boil the juice for about ſix hours. In that time it comes to the ſweetneſs and conſiſtency, and anſwers all the purpoſes of other molaſſes.

5. There is one ſea-production, if it may be ſo termed, that is not commonly underſtood. Some have maintained, that ambergris was a ſubſtance naturally bred in one ſpecies of whales, in a bag three or four feet long. But this bag is in truth only the bladder of the whales, and the ſuppoſed ambergris is only a calculus of the bladder. The largeſt of theſe ever found in a whale, weighed twenty-one pounds. But pieces of ambergris have been found, which were ſix feet long, and weighed above 180 pounds.

It ſeems, 1. That ambergris, like yellow amber, comes out of the earth into the ſea. 2. That it comes not like napththa, but in a thicker viſcid and tenacious conſiſtence. 3. That in the firſt formation thereof, a liquid bitumen or napththa is mixed with it. 4. That large pieces may be generated at the ſame time; but uſually a ſmall one riſes firſt, to which another ſoon adheres, and ſo more and more, forming irregular figures, under which it is ſoft, ſo that various ſubſtances ſtick to it: but it gradually hardens to the conſiſtence of wax.

However, one would not be poſitive as to the manner of its generation. For who can explain in what manner amber is produced? Or how metals, ſemimetals, precious ſtones, and innumerable other mineral ſubſtances are generated? We know what they are, but how they are formed, we know not with any degree of certainty.

6. The principle of corruption in plants and animals, is probably the very ſame, which during a ſtate of circulation, is the principle of life: namely the air, which is found in conſiderable quantities, mixed with all ſorts of fluids. This has two very different motions; an expanſive one, ariſing from its natural elaſticity, by which it gives their fluids an inteſtine motion, and gradually extends the parts that contain them: and a progreſſive motion. It does not appear that this is eſſential to it. Rather it is occaſioned by the reſiſtance of the

the ſolid parts. This reſtraining its expanſion, obliges it to take the courſe that is more free and open, which is through the veſſels of plants and animals.

When this courſe is ſtopped, the expanſive motion remains, and ſtill continues to act, till it has ſo fully overcome the including bodies, as to bring itſelf to the ſame degree of expanſion with the outward air. But this it cannot do, without deſtroying the texture and continuity of thoſe ſolids, which we call corruption.

The deſtructive quality of the air is promoted, either by weakening the tone or coheſion of the including parts; as when fruit is bruiſed, which corrupts in that part much ſooner than in the others: or by increaſing the expanſive force of the air, by heat, or ſome other co-operating circumſtance.

And certainly there is no corruption or putrefaction, without air. Hence either vegetable or animal bodies buried deep in the earth or water, remain for ages entire, which when expoſed to the air, quickly moulder away. And hence ſuch vegetables as are moſt apt to putrify, remain unchanged in vacuo.

Yet various experiments ſeem to ſhew, that air muſt be impregnated by water, before it can occaſion putrefaction, either in animal or vegetable ſubſtances. For take a pound of freſh fleſh, and keep it in a moderate heat, and it will thoroughly putrify in a few days. But if you firſt extract the moiſture, it will harden like a ſtone. And it may then be kept for ages, without any putrefaction. Even blood, if you deprive it of its watry part may be kept for fifty years. But if you then diſſolve it in water, and place it in a gentle warmth, it it will putrify immediately.

The proceſs of putrefaction may be learned from an eaſy experiment. Take the green, juicy parts of any freſh vegetable, throw them together in a large heap, in a warm air, and lay a weight upon them. The middle part of the heap will ſoon conceive a ſmall degree of heat. It will come hotter and hotter, till it comes to a boiling heat, and is perfectly putrified.

In three days from the firſt putting them together the heat will equal that of a human body in health. By the fifth day the heat will be ſuch as the hand, can hardly bear. By the ſeventh or eighth, all the juices are generally ready to boil. Sometimes the matter will

even

even flame, (as does moiſt hay) till it burns away. But commonly it acquires a cadaverous taſte and ſmell, and turns into one ſoft, pulpy maſs, much reſembling human excrements in the ſcent, and putrified fleſh in the taſte.

If this be diſtilled, there will come from it, 1. An urinous ſpirit, perfectly like that obtained from animals, and ſeparable by freſh diſtillation into pure water, and a large quantity of white, dry, volatile ſalt, not to be diſtinguiſhed from animal ſalts. 2. An oily ſalt, which ſhoots into globes. 3. A thick fætid oil, both which are entirely like thoſe of animals. 4. The remainder being calcined in an open fire yields not the leaſt particle of fixed ſalt: juſt as if the ſubject had been of the animal, not the vegetable kingdom. And this proceſs holds equally in all kinds of vegetables, though of ever ſo different natures. Yea, in dry vegetables, ſo they be moiſtened by water, before they are thrown into heaps.

By this means the difference between one vegetable and another is entirely taken away. By this proceſs, they are all reduced to one common nature: ſo that wormwood for example, and ſage, become one and the ſame thing. Nay, by this means the difference between vegetables and animals is quite taken away; putrified vegetables being no way diſtinguiſhable from putrified fleſh. Thus is there an eaſy reciprocal tranſition of animal into vegetable, and vegetable into animal.

So true it is, that matter, as matter, has no concern, in the qualities of bodies. All depend on the arrangement of the particles, whereof each particle conſiſts. Hence water, though taſteleſs, feeds aromatic mint, and the ſame earth gives nouriſhment to bread and poiſon.

As to this arrangement, the firſt view of a vegetable gives us an idea, of infinitely numerous and various parts: and ſo complex, that many have been diſcouraged from proſecuting the reſearch. But upon examination, the parts which appear ſo numerous, are reduced to a very ſmall account. For a careful maceration in ſoft water will ſhew, that the parts really diſtinct are only ſeven. Theſe are, 1. An outer bark, 2. An inner rind, 3. A blea, 4. A fleſhy ſubſtance, 5. A pith. There is between the fleſh and the blea, 6. A vaſcular

ſeries

ſeries, and 7. Cones of veſſels take their courſe within the fleſh.

Whatever part of the plant we examine, we find theſe, be it a fibre, the root or the ſtem. We never find more: and tracing theſe, we ſee the other parts of the plants are only the productions of them. Thus the root, its deſcending fibre, and the aſcending ſtalk, we find are one, not three ſubſtances. The ſame ſeven parts are continued from one to the other, and what are ſuppoſed at its ſummit, to be many new and ſtrange parts, are found to be no more than the terminations of theſe ſeven. The external parts are alſo ſeven. 1. The cup, 2. The outer petals, 3. The inner petals, 4. The nectaria, either diſtinct, or connected in one ring, 5. The filaments, 6. The receptacle of ſeeds, and 7. The ſeed-veſſel or ſeeds. And theſe are only the terminations of the ſeven conſtituent ſubſtances of the plant. The outer bark terminates in the cup, the inner rind in the outward petals; the blea forms the inner petals, the vaſcular ſeries ends in the nectaria, and the fleſh in the filaments: the cones form the receptacle, the pith, the ſeed, and their capſules. Theſe are univerſal in plants, though their courſe be leſs plain in ſome and their terminations leſs diſtinct in others.

Every piece therefore cut from a plant tranſverſely contains all the parts of the plant, ready to grow in length into a ſtalk upwards, and into a root downwards, and to ſeparate at a due height from the root, into the ſeveral parts of the flower.

Thus we ſee the arrangement of the common particles of matter into a vegetable body, although it be a work worthy of his hand who formed it, yet is not ſo complex a thing as it appears. And this arrangement being once made in one individual, the ſpecies is created for ever. For growth is the conſequence of the arrangement, when it has heat and moiſture.

Upon the whole: if we conſider every part of a plant, we ſhall find none without its uſe. The root draws nouriſhment from the earth: the fibres convey the ſap, the larger veſſels contain the ſpecific juice of the plant: others carry air for ſuch a reſpiration as it needs. The outer and inner bark in trees, defend them from heat and cold and drought, and convey that ſap which is required

quired for the annual increaſe of the tree. And in truth every tree may in ſome ſenſe be ſaid to be an annual plant. For both leaf, flower and fruit proceed from the coat that was ſuperinduced over the wood the laſt year. And this never bears more, but together with the old wood ſerves as a block to ſuſtain the ſucceeding annual coat. The leaves ſerve, before the bud unfolds to defend the flower and fruit, which is even then formed; and afterward to preſerve them and the branches from the injuries of the ſummer ſun. They ſerve alſo to hinder the too haſty evaporation of the moiſture about the root. But their chief uſe is to concoct the ſap, for the nouriſhment of the whole plant: both that they receive from the root, and that they take in from the dew, the rain, and the moiſt air. Add to this, that they are as lungs, which ſupply the plant with the neceſſary quantity of air, and as excremental ducts, which throw off ſuperfluities by inſenſible perſpiration. And ſo neceſſary is their ſervice, that moſt trees, if quite ſtript of their leaves, will die. And if in ſummer you ſtrip a vine-branch of its leaves, the grapes will never come to maturity. Not that they are hurt by the ſun: expoſe them to this as you pleaſe, ſo the leaves remain, and they will ripen well.

Another point worthy our conſideration is, the immenſe ſmallneſs of the ſeeds of ſome plants. Some are ſo extremely minute, as not at all to be diſcovered by the naked eye. Hence the number of ſeeds produced by ſome plants, is beyond imagination. A plant of redmace, for inſtance, and many ſorts of fern, produce above a million: a convincing argument of the infinite underſtanding of the Former of them.

And it is remarkable, that ſuch moſſes as grow upon walls, the roofs of houſes and other high places, have ſeeds ſo exceſſively ſmall, that when ſhaken out of their veſſels they appear like ſmoke or vapour. Theſe therefore may either aſcend of themſelves, or by an eaſy impulſe of the wind be raiſed to the tops of walls, houſes, or rocks. And we need not wonder how the moſſes got thither, or imagine they ſprung up ſpontaneouſly.

Concerning vegetables in general we may farther remark,

remark, 1. That becauſe they are intended to be food for numberleſs ſpecies of animals, therefore nature has taken ſo extraordinary care, and made ſo abundant proviſion, for their propagation and increaſe. So that they are propagated and multiplied, not only by the ſeed, but alſo by the root: producing ſhoots or off-ſets in ſome, creeping under-ground in others. Some likewiſe are propagated by ſlips or cuttings; and ſome by ſeveral of theſe ways. Secondly, for the ſecurity of ſuch ſpecies as are produced only by ſeed, moſt ſeeds are endued with a laſting vitality; ſo that if by reaſon of exceſſive cold or drought, or any other accident, they happen not to ſpring up the firſt year, they may continue their fruitfulneſs, I do not ſay, ſix or ſeven only, but even twenty or thirty years. Nay, after this term, if the hinderance be removed, they will ſpring, and bring forth fruit. Hence it is, that plants are ſometimes loſt for a conſiderable time, in places wherein they abounded before. And after ſome years appear anew. They are loſt either becauſe of the unfavourable ſeaſons; becauſe the land was fallowed; or becauſe plenty of weeds, or other plants, prevented their coming up. And as ſoon as theſe impediments are removed they ſpring up again. Thirdly, Many vegetables are armed with prickles or thorns, to ſecure them from the browzing of beaſts; as alſo to defend others, which grow under their ſhelter. Hereby likewiſe they are made particularly uſeful to man, either for quick or dead fences. Fourthly, ſuch vegetables as are weak and not able to ſupport themſelves, have a wonderful faculty, to uſe the ſtrength of their neighbours, embracing and climbing up upon them, and uſing them as crutches to their feeble bodies. Some twiſt themſelves about others like a ſcrew: ſome lay faſt hold upon them, by their curious claſpers or tendrils, which herein are equivalent to hands. Some ſtrike in a kind of root: others by the emiſſion of a natural glue, firmly adhere to any thing which has ſtrength ſufficient to ſupport them. Claſpers are of a compound nature, between a root and a branch. Sometimes they ſerve for ſupport only; as in the claſpers of vines, whoſe branches being long and ſlender, would otherwiſe ſink with their own weight: ſometimes, for a ſupply of nouriſhment alſo;

as

as in the trunk roots of ivy; which mounting very high and being of a close and very compact nature, the sap would not be sufficiently supplied to the upper sprouts, unless these assisted the mother root. Fifthly, the best of all grain, and what affords the most wholesome and agreeable nourishment is wheat. And it is most patient of all climates, bearing the extremes both of heat and cold. It grows, and brings its seed to maturity, not only in the temperate countries, but also in the cold regions of Scotland, Denmark, Norway, and Muscovy, on the one hand; and on the other, in the sultry heat of Spain, Egypt, Barbary, Mauritania, and the East-Indies. Nor is it less observable, that nothing is more fruitful. One bushel when sown in a proper soil, having been found to yield a hundred and fifty, and in some instances abundantly more.

7. It may be of use to subjoin here, first a general view of vegetation, secondly, some additional reflections on the vegetable kingdom.

And first. As to vegetation itself, we are sensible all our reasonings about the wonderful operations of nature, are so full of uncertainty, that as the wise man truly observes, "Hardly do we guess aright at the things which are upon earth, and with labour do we find the things that are before us." This is abundantly verified in vegetable nature. For though its productions are so obvious to us, yet are we strangely in the dark concerning them, because the texture of their vessels is so fine and intricate that we can trace but few of them, though assisted with the best microscopes. But although we can never hope to come to the bottom of the first principle of things, yet may we every where see plain signatures of the hand of a divine architect.

All vegetables are composed of water and earth, principles which strongly attract each other: and a large portion of air, which strongly attracts when fixed, but strongly repels when in an elastic state. By the combination, action, and re-action of those few principles all the operations in vegetables are effected.

The particles of air distend each ductile part, and invigorate their sap, and meeting with the other mutually

tually attracting principles, they are by gentle heat and motion enabled to aſſimilate into the nouriſhment of the reſpective parts. Thus nutrition is gradually advanced, by the nearer and nearer union of theſe principles, till they arrive at ſuch a degree of conſiſtency, as to form the ſeveral parts of vegetables. And at length by the flying off of the watry vehicle, they are compacted into hard ſubſtances.

But when the watry particles again ſoak into and diſunite them, then is the union of the parts of vegetables diſſolved, and they are prepared by putrefaction, to appear in ſome new form, whereby the nutritive fund of nature can never be exhauſted.

All theſe principles are in all the parts of vegetables. But there is more oil in the more exalted parts of them. Thus ſeeds abound with oil, and conſequently with ſulphur and air. And indeed as they contain the rudiments of future vegetables, it was neceſſary they ſhould be ſtored with principles, that would both preſerve them from putrefaction, and alſo be active in promoting germination and vegetation.

And as oil is an excellent preſervative againſt cold, ſo it abounds in the ſap of the more northern trees. And it is this by which the ever-greens are enabled to keep their leaves all the winter.

Leaves not only bring nouriſhment from the lower parts within the attraction of the growing fruit, (which like young animals is furniſhed with proper inſtruments to ſuck it thence) but alſo carry off redundant watry fluids, while they imbibe the dew and rain, which contain much ſalt and ſulphur, for the air is full of acid and ſulphureous particles; and the various combinations of theſe, are doubtleſs very ſerviceable in promoting the work of vegetation. Indeed ſo fine a fluid as the air is a more proper medium, wherein to prepare and combine, the more exalted principles of vegetables, than the groſs watry fluid of the ſap. And that there is plenty of theſe particles in the leaves is evident, from the ſulphureous exudations often found on their edges. To theſe refined aëreal particles, not only the moſt racy, generous taſte of fruits, but likewiſe the moſt grateful odours of flowers, yea, and their beautiful colours are probably owing.

In order to ſupply tender ſhoots with nouriſhment, nature

nature is careful to furniſh, at ſmall diſtances, the young ſhoots of all ſorts of trees, with many leaves throughout their whole length which as ſo many jointly acting powers, draw plenty of ſap to them.

The like proviſion has nature made, in the corn, graſs, and reed-kind: the leafy ſpires, which draw nouriſhment to each joint, being provided long before the ſtem ſhoots: the tender ſtems would eaſily break, or dry up, ſo as to prevent their growth, had not theſe ſcabbards been provided, which both ſupport and keep them in a ſupple and ductile ſtate.

The growth of a young bud to a ſhoot, conſiſts in the gradual dilatation and extenſion of every part, till it is ſtretched out to its full length. And the capillary tubes ſtill retain their hollowneſs, notwithſtanding their being extended, as we ſee melted glaſs-tubes remain hollow, though drawn out to the fineſt thread.

The pith of trees is always full of moiſture, while the ſhoot is growing, by the expanſion of which, the tender, ductile ſhoot is diſtended in every part. But when each year's ſhoot is fully grown, then the pith gradually dries up. Mean time nature carefully provides for the growth of the ſucceeding year, by preſerving a tender, ductile part in the bud, replete with ſucculent pith. Great care is likewiſe taken to keep the parts between the bark and wood always ſupple with ſlimy moiſture, from which ductile matter the woody fibres, veſicles, and buds are formed.

The great variety of different ſubſtances in the ſame vegetable proves, that there are peculiar veſſels for conveying different ſorts of nutriment. In many vegetables ſome of thoſe veſſels are plainly ſeen full of milky, yellow, or red nutriment.

Where a ſecretion is deſigned to compoſe a hard ſubſtance, viz. the kernel or ſeed of hardſtone fruits, it does not immediately grow from the ſtone, which would be the ſhorteſt way to convey nouriſhment to it. But the umbilical veſſel fetches a compaſs round the concave of the ſtone, and then enters the kernel near its cone. By this artifice the veſſel being much prolonged, the motion of the ſap is thereby retarded, and a viſcid nutriment conveyed to the ſeed, which turns to a hard ſubſtance.

Let us trace the vegetation of a tree, from the ſeed

to its full maturity. When the ſeed is ſown, in a few days it imbibes ſo much moiſture, as to ſwell with very great force, by which it is enabled both to ſtrike its roots down, and to force its ſtem out of the ground. As it grows up, the firſt, ſecond, third, and fourth order of lateral branches ſhoot out, each lower order being longer than thoſe immediately above them: not only as ſhooting firſt, but becauſe inſerted nearer the root, and ſo drawing greater plenty of ſap. So that a tree is a complicated engine, which has as many different powers as it has branches. And the whole of each yearly growth of the tree, is proportioned to the whole of the nouriſhment it attracts.

But leaves alſo are ſo neceſſary to promote its growth, that nature provides ſmall, thin, expanſions, which may be called primary leaves, to draw nouriſhment to the buds and young ſhoots, before the leaf is expanded. Theſe bring nutriment to them in a quantity ſufficient for their ſmall demand: a greater quantity of which is afterward provided, in proportion to their need, by the greater expanſion of the leaves. A ſtill more beautiful apparatus we find in the curious expanſions of bloſſoms and flowers, which both protect and convey nouriſhment to the embryo, fruit and ſeeds. But as ſoon as the calix is formed into a ſmall fruit, containing a minute ſeminal tree, the bloſſom falls off, leaving it to imbibe nouriſhment for itſelf, which is brought within the reach of its ſuction, by the adjoining leaves.

I proceed to make ſome additional reflections upon the vegetable kingdom.

All plants produce ſeeds; but they are entirely unfit for propagation, till they are impregnated. This is performed within the flower, by the duſt of the Antheræ falling upon the moiſt ſtigmata, where it burſts and ſends forth a very ſubtle matter, which is abſorbed by the ſtyle, and conveyed down to the ſeed. As ſoon as this operation is over, thoſe organs wither and fall. But one flower does not always contain all theſe: often the male organs are on one, the female, on another. And that nothing may be wanting, the whole apparatus of the antheræ and ſtigmata is in all flowers contrived with wonderful wiſdom. In moſt, the ſtigmata ſurround the piſtil, and are of the ſame height. But where the

piſtil

piſtil is longer than the ſtigmata, the flowers recline, that the duſt may fall into the ſtigma, and when impregnated riſe again, that the ſeeds may not fall out. In other flowers the piſtil is ſhorter, and there the flowers preſerve an erect ſituation. Nay, when the flowering ſeaſon comes on, they become erect though they were drooping before. Laſtly, when the male flowers are placed below the female, the leaves are very ſmall and narrow, that they may not hinder the duſt from flying upwards like ſmoke: and when in the ſame ſpecies one plant is male, and the other female, there the duſt is carried in abundance by the wind from the male to the female. We cannot alſo without admiration obſerve, that moſt flowers expand themſelves when the ſun ſhines, and cloſe when either rain, clouds, or evening is coming on, leaſt the genital duſt ſhould be coagulated, or otherwiſe rendered uſeleſs. Yet when the impregnation is over, they do not cloſe, either upon ſhowers, or the approach of evening.

For the ſcattering of ſeed nature has provided numberleſs ways. Various berries are given for food to animals; but while they eat the pulp, they ſow the ſeed. Either they diſperſe them at the ſame time: or if they ſwallow them, they are returned with intereſt. The miſtletoe always grows on other trees; becauſe the thruſh that eats the ſeeds of them, caſts them forth with his dung. The junipers alſo, which fill our woods, are ſown in the ſame manner. The croſs-bill that lives on fir-cones, and the haw-finch which feeds on pine-cones, ſow many of thoſe ſeeds, eſpecially when they carry the cone to a ſtone or ſtump, to ſtrip off its ſcales. Swine likewiſe and moles by throwing up the earth, prepare it for the reception of ſeeds.

The great parent of all decreed that the whole earth ſhould be covered with plants. In order to this he adapted the nature of each to the climate where it grows. So that ſome can bear intenſe heat, others intenſe cold. Some love a moderate warmth. Many delight in dry, others in moiſt ground. The Alpine plants love mountains whoſe tops are covered with eternal ſnow. And they blow and ripen their ſeeds very early, leſt the winter ſhould overtake and deſtroy them. Plants which will grow no where elſe, flouriſh

in Siberia, and near Hudſon's Bay. Graſs can bear almoſt any temperature of the air, in which the good providence of God appears: this being ſo neceſſary all over the globe, for the nouriſhment of cattle.

Thus neither the ſcorching ſun, nor the pinching cold hinders any country from having its vegetables. Nor is there any ſoil which does not bring forth ſome. Pond-weed and water-lillies inhabit the waters. Some plants cover the bottom of rivers and ſeas: others fill the marſhes. Some clothe the plains: others grow in the drieſt woods, that ſcarce ever ſee the ſun. Nay, ſtones and the trunks of trees are not void, but covered with liver wort.

The wiſdom of the Creator appears no where more, than in the manner of the growth of trees. As their roots deſcend deeper than thoſe of other plants, they do not rob them of nouriſhment. And as their ſtems ſhoot up ſo high, they are eaſily preſerved from cattle. Their leaves falling in Autumn guard many plants againſt the rigor of winter: and in the ſummer afford both them and us a defence againſt the heat of the ſun. They likewiſe imbibe the water from the earth, part of which tranſpiring through their leaves, is inſenſibly diſperſed, and helps to moiſten the plants that are round about. Laſtly, the particular ſtructure of trees contributes very much to the propagation of inſects. Multitudes of theſe lay their eggs upon their leaves, where they find both food and ſafety.

Many plants and ſhrubs are armed with thorns, to keep the animals from deſtroying their fruits. At the ſame time theſe cover many other plants, under their branches, ſo that while the adjacent grounds are robbed of all plants, ſome may be preſerved to continue the ſpecies.

The moſſes which adorn the moſt barren places, preſerve the ſmaller plants when they begin to ſhoot from cold and drought. They alſo hinder the fermenting earth from forcing the roots of plants upward in the ſpring, as we ſee happen annually to trunks of trees. Hence few moſſes grow in ſouthern climates, not being neceſſary.

Sea-matweed will bear no ſoil but pure ſand. Sand is often blown by violent winds, ſo as to deluge as it were

were meadows and fields. But where this grows, it fixes the ſand, and gathers it into hillocks. Thus other lands are formed, the ground increaſed, and the ſea repelled, by this wonderful diſpoſition of nature.

How careful is nature to preſerve that uſeful plant graſs? The more its leaves are eaten, the more they increaſe. For the Author of Nature intended, that vegetables which have ſlender ſtalks and erect leaves ſhould be copious and thick ſet, and thus afford food for ſo vaſt a quantity of grazing animals. But what increaſes our wonder, is, that although graſs is the principal food of ſuch animals, yet they touch not the flower and ſeed bearing ſtems, that ſo the ſeeds may ripen and be ſown.

The caterpillar of the moth, which feeds upon graſs to the deſtruction thereof ſeems to be formed in order to keep a due proportion between this and other plants. For graſs when left to grow freely, increaſes to that degree as to exclude all other plants, which would conſequently be extirpated, unleſs the inſect ſometimes prepared a place for them. And hence it is, that more ſpecies of plants appear, when this caterpillar has laid waſte the paſture the preceding year, than at any other time.

But all plants ſooner or later, muſt ſubmit to death. They ſpring up, they grow, they flouriſh, they bear fruit, and having finiſhed their courſe, return to the duſt again. Almoſt all the black mould which covers the earth is owing to dead vegetables. Indeed after the leaves and ſtems are gone, the roots of plants remain: but theſe too, at laſt rot and change into mould. And the earth thus prepared, reſtores to plants what it has received from them. For when ſeeds are committed to the earth, they draw and accommodate to their own nature the more ſubtle parts of this mould: ſo that the talleſt tree is in reality nothing but mould wonderfully compounded with air and water. And from theſe plants, when they die, juſt the ſame kind of mould is formed as gave them birth. By this means fertility remains continually uninterrupted: whereas the earth could not make good its annual conſumption, were it not conſtantly recruited.

In

In many caſes, the cruſtaceous liverworts are the firſt foundation of vegetation. Therefore however deſpiſed, they are of the utmoſt conſequence, in the œconomy of nature. When rocks firſt emerge out of the ſea, they are ſo poliſhed by the force of the waves, that hardly any herb is able to fix its habitation upon them. But cruſtaceous liverworts ſoon begin to cover theſe dry rocks, though they have no nouriſhment but the little mould and imperceptible particles, which the rain and air bring thither. Theſe liverworts dying turn into fine earth, in which a larger kind of liverworts ſtrike their roots. Theſe alſo die and turn to mould: and then the various kinds of moſſes find nouriſhment. Laſtly, theſe dying yield ſuch plenty of mould, that herbs and ſhrubs eaſily take root and live upon it.

That trees, when dry or cut down, may not remain uſeleſs to the world, and lie melancholy ſpectacles, nature haſtens on their deſtruction, in a ſingular manner. Firſt the liverworts begin to ſtrike root in them; afterward the moiſture is drawn out of them, whence putrefaction follows. Then the muſhroom-kind find a fit place to grow on, and corrupt them ſtill more. A particular ſort of beetle next makes himſelf a way between the bark and the wood. Then a ſort of caterpillar and ſeveral other ſorts of beetles, bore numberleſs holes through the trunk. Laſtly, the wood-peckers come, and while they are ſeeking for inſects, ſhatter the tree already corrupted, and exceedingly haſten its return to the earth from whence it came. But how ſhall the trunk of a tree, which is immerſed in water, ever return to earth? A particular kind of worm performs this work, as ſea-faring men well know.

But why is ſo inconſiderable a plant as thiſtles, ſo armed and guarded by nature? Becauſe it is one of the moſt uſeful plants that grows. Obſerve a heap of clay, on which for many years no plant has ſprung up: let but the ſeeds of a thiſtle fix there, and other plants will quickly come thither, and ſoon cover the ground. For the thiſtles by their leaves attract moiſture from the air, and by their roots ſend it into the clay, and by that means not only thrive themſelves, but provide a ſhelter for other plants.

I ſhall

I ſhall add only one obſervation more, concerning the difference between natural and artificial things. If we examine the fineſt needle by the microſcope, the point of it appears about a quarter of an inch broad, and its figure neither round, nor flat, but irregular and unequal. And the ſurface, however ſmooth and bright it may ſeem to the naked eye, is then ſeen full of raggedneſs, holes, and ſcratches, like an iron bar from the forge. But examine in the ſame manner the ſting of a bee, and it appears to have in every part a poliſh moſt amazingly beautiful, without the leaſt flaw or inequality, and ends in a point too fine to be diſcerned by any glaſs whatever. And yet this is only the outward ſheath of far more exquiſite inſtruments.

A ſmall piece of the fineſt lawn, from the diſtance and holes between its threads, appears like a lattice or hurdle. And the threads themſelves ſeem coarſer than the yarn wherewith ropes are made for anchors. Fine Bruſſels lace will look as if it were made of a thick, rough, uneven hair-line, untwiſted or clotted together in a very aukward and unartful manner. But a ſilk-worm's webb on the niceſt examination appears perfectly ſmooth and ſhining, and as much finer than any ſpinſter in the world can make, as the ſmalleſt twine is than the thickeſt cable. A pod of this ſilk winds into nine hundred and ſixty yards. And as it is two threads twiſted together all the length, ſo it really contains one thouſand eight hundred and ſixty: and yet weighs but two grains and a half. What an exquiſite fineneſs! and yet this is nothing to the ſilk that iſſued from the worm's mouth when newly hatched.

The ſmalleſt dot which can be made with a pen, appears through a glaſs, a vaſt irregular ſpot, rough, jagged and uneven about all its edges. The fineſt writing (ſuch as the Lord's Prayer in the compaſs of a ſilver penny) ſeems as ſhapeleſs and uncouth as if wrote in runic characters. But the ſpecks of moths, beetles, flies, and other inſects, are moſt accurately circular; and all the lines and marks above them are drawn, to the utmoſt poſſibility of exactneſs.

Our fineſt miniature paintings appear before a microſcope, as mere daubings, plaiſtered on with a trowel. Our ſmootheſt poliſhings are ſhewn to be mere roughneſs,

roughneſs, full of gaps and flaws. Thus do the works of art ſink, upon an accurate examination. On the contrary, the nearer we examine the works of nature, even in the leaſt and meaneſt of her productions, the more we are convinced, nothing is to be found there, but beauty and perfection. View the numberleſs ſpecies of inſects, what exactneſs and ſymmetry ſhall we find in all their organs? What a profuſion of colouring, azure, green, vermillion: what fringe and embroidery on every part! How high the finiſhing, how inimitable the poliſh we every where behold! Yea, view the animalcula, inviſible to the naked eye, thoſe breathing atoms ſo ſmall, they are almoſt all workmanſhip: in them too we diſcover the ſame multiplicity of parts, diverſity of figures, and variety of motions, as in the largeſt animals. How amazingly curious muſt the internal ſtructure of theſe creatures be! How minute the bones, joints, muſcles, and tendons! How exquiſitely delicate the veins, arteries, nerves! What multitudes of veſſels and circulations muſt be contained in this narrow compaſs! And yet all have ſufficient room for their ſeveral offices, without interfering with each other.

The ſame regularity and beauty is found in vegetables. Every ſtalk, bud, flower, and ſeed, diſplays a figure, a proportion, a harmony, beyond the reach of art. There is not a weed whoſe every leaf does not ſhew a multiplicity of pores and veſſels curiouſly diſpoſed for the conveyance of juices, to ſupport and nouriſh it, and which is not adorned with innumerable graces to embelliſh it.

But ſome may aſk, to what purpoſe has nature beſtowed ſo much expenſe on ſo inſignificant creatures? I anſwer, this very thing proves they are not ſo inſignificant, as we fondly ſuppoſe. This beauty is given them either for their own ſake, that they themſelves may be delighted with it: or for ours, that we may obſerve in them the amazing power and goodneſs of the Creator. If the former, they are of conſequence in the account of their Maker, and therefore deſerve our regard. If the latter, then it is certainly our duty to take notice of, and admire them.

In ſhort, the whole univerſe is a picture, in which are diſplayed the perfections of the deity. It ſhews not only his exiſtence, but his unity, his power, his wiſdom, his independence, his goodneſs. His unity appears in the harmony we cannot but ſee in all the parts of nature; in that one ſimple end to which they are directed, and the conformity of all the means thereto. On every ſide we diſcern either ſimple elements or compound bodies, which have all different actions and offices. What the fire inflames, the water quenches: what one wind freezes, another thaws. But theſe and a thouſand other operations, ſo ſeemingly repugnant to each other, do nevertheleſs all concur in a wonderful manner, to produce one effect. And all are ſo neceſſary to the main deſign, that were the agency of any one deſtroyed, an interruption of the order and harmony of the creation muſt immediately enſue.

Suppoſe, for inſtance, the wind to be taken away, and all ſociety is in the utmoſt diſorder. Navigation is at a ſtand, and all our commerce with foreign nations deſtroyed. On the other hand the vapours raiſed from the ſea would remain ſuſpended juſt where they roſe. Conſequently we ſhould be deprived of that uſeful covering the clouds, which now ſcreens us from the ſcorching heat: yea, and of the fruitful rains. So our land would be parched up, the fruits of the earth wither, animals die, through hunger and thirſt, and all nature languiſh and droop. All the parts of nature therefore were conſtituted for the aſſiſtance of each other, and all undeniably prove the unity of their omniſcient Creator.

His power appears in the whole frame of creation, and his wiſdom in every part of it. His independence is pointed out in the inexhauſtible variety of beaſts, birds, fiſhes and inſects: and his goodneſs, in taking care of every one of theſe, opening his hand, and filling all things living with plenteouſneſs.

Every thing is calculated by divine wiſdom, to make us wiſer and better. And this is the ſubſtance of true philoſophy. We cannot know much. In vain does our ſhallow reaſon attempt to fathom the myſteries of nature, and to pry into the ſecrets of the Almighty. "His ways are paſt finding out." The eye of a little

worm is a ſubject capable of exhauſting all our boaſted ſpeculations. But we may love much. And herein we may be aſſiſted by contemplating the wonders of his Creation. Indeed he ſeems to have laid the higheſt claim to this tribute of our love, by the care he has taken to manifeſt his goodneſs in the moſt conſpicuous manner, while at the ſame time he has concealed from us the moſt curious particulars, with regard to the eſſences and ſtructure of his works. And to our ignorance it is owing, that we fancy ſo many things to be uſeleſs in the Creation. But a deep ſenſe of his goodneſs will ſatisfy all our doubts, and reſolve all our ſcruples.

8. I cannot conclude this part better, than with an eſſay on the production, nouriſhment, and operation of plants and animals.

SECT. I.

Creatures produce their own Kind.

WHEN I ſurvey the works of nature with an attentive eye, I am ſurpriſed to find with what marvellous exactneſs every creature draws its own picture, or propagates its own likeneſs, though in different manners of operation. The fox produces a living fox; the gooſe drops her egg, and hatches the young gooſe; and the tulip lets fall its ſeed into the earth, which ferments and ſwells, and labours long in the ground, till at laſt it brings forth a tulip.

Is it the natural ſagacity of foxes that enables them to form their own image ſo accurately? By no means: for the gooſe and the flower do the like: the ſprightly and the ſtupid, the ſenſible and the ſenſeleſs, work this wonder with equal regularity and perfection; and the plant performs it as well as the animal.

It is not poſſible that any of them ſhould effect this by any peculiar rules of art and contrivance: for neither the one nor the other are at all acquainted with the compoſition or progreſs of their work. The bird is entirely ignorant of the wondrous vital ferment of her own egg, either in the formation of it, or the incubation:

cubation: and the mother-plant knows as much of the parts of the young plant, as the mother-animal knows of the inward ſprings and movements of the young little-animal. There could be no contrivance here: for not any of them had any thought or deſign of the final production: they were all moved, both the beaſt, bird and flower, by the material and mechanical ſprings of their own nature to continue their own ſpecies, but without any ſuch intent or purpoſe.

Give ſouls to all the animal race, and make thoſe ſouls as intelligent as you can; attribute to them what good ſenſe you pleaſe in other affairs of their puny life; allow the brutes to be as rational and as cunning as you could wiſh or fancy, and to perform a thouſand tricks by their own ſagacity; yet in this matter, thoſe intellectual powers muſt all ſtand by as uſeleſs: the ſenſeleſs vegetable has as much ſkill here as the animal: the gooſe is as wiſe as the fox or the greyhound; they draw their own portraits with as exquiſite art and accuracy, and leave as perfect images behind them to perpetuate their kind. Amazing proof and inconteſtible argument of ſome ſuperior wiſdom: ſome tranſcendent contriving mind: ſome divine artificer that made all theſe wondrous machines, and ſet them at work! The animal and the vegetable in theſe productions are but mere inſtruments under his ſupreme ruling power; like artleſs pencils in a painter's hand, to form the images that his thought had before deſigned: and it is that God alone, who before all worlds contrived theſe models of every ſpecies in his own original idea, that appoints what under agents he will employ to copy them.

In the week of the Creation, he bade the earth teem with beaſts and plants: and the earth like a common mother brought forth the lion, the fox and the dog, as well as the cedar and the tulip, Gen. i. 11. 24. He commanded the water to produce the firſt fiſh and fowl: behold the waters grow pregnant; the trout and the dolphin break forth into life; the gooſe and the ſparrow ariſe and ſhake their wings, Gen. i. 20, 21. But two common parents, earth and water to the whole animal and vegetable world! A God needs no more. And though he was pleaſed to make uſe of the water

and

and the earth in theſe firſt productions, yet the power and the ſkill were juſt the ſame as if he had made them immediately with his own hands.

Ever ſince that week of creative wonders, God has ordered all theſe creatures to fill the world with inhabitants of their own kind; and they have obeyed him in a long ſucceſſion of almoſt ſix thouſand years. He has granted (ſhall I ſay) a divine patent to each creature for the ſole production of its own likeneſs, with an utter prohibition to all the reſt; but ſtill under the everlaſting influence of his own ſupreme agency upon the moving atoms that form theſe plants or animals. God himſelf is the Creator ſtill.

And it is evident that he has kept a reſerve of ſovereignty to himſelf, and has diſplayed the enſigns of it in ſome important hours. Egypt was once a glorious and tremendous ſcene of this ſovereignty: it was there that he ordered the rod of Moſes, a dry and lifeleſs vegetable, to raiſe a ſwarm of living animals, to call up a brood of lice in millions without a parent, and to animate the duſt of the ground into a noiſome army.

It was there he bid Moſes wave the ſame rod over the ſtreams and the ponds, and the ſilent rod under divine influence would bring forth croaking legions out of the waters without number.

But theſe are his works of miracle and aſtoniſhment, when he has a mind to ſhew himſelf the ſovereign and the controller of nature: without his immediate commiſſion not one creature can invade the province of another, nor perform any thing of this work but within its own peculiar tribe. Even man the glory of this lower creation and the wiſeſt thing on earth, would in vain attempt to make one of theſe common vegetables, or theſe curious animated moving machines. Not all the united powers of human nature, nor a council of the niceſt artificers with all their enginry and ſkill, can form the leaſt part of theſe works, can compoſe a fox's tail, a gooſe-quill, or a tulip-leaf. Nature is the art of God, and it muſt for ever be unrivalled by the ſons of men.

Yet man can produce a man. Admirable effect, but artleſs cauſe! A poor, limited, inferior agent! The plant and the brute in this matter are his rivals, and his

his equals too. The human parent and the parent bird form their own images with equal ſkill, and are confined each to its own work. So the iron ſeal transfers its own figure to the clay with as much exactneſs and curioſity as the golden one: both can transfer only their own figure.

This appears to me a glorious inſtance wherein the wiſdom and power of God maintain their own ſupremacy, and triumph over all the boaſted reaſon and intellectual ſkill of men: that the wiſeſt ſon of Adam in this nobleſt work of nature, can do no more than a flower or a fly; and if he would go out of his own ſpecies, and the appointed order of things, he is not able to make a fly, or a flower; no, not a worm, nor a ſimple bulruſh. In thoſe productions wherein mankind are merely the inſtruments of the God of Nature, their work is vital and divine; but if they would ſet up for prime artificers, they can do nothing: a dead ſtatue, a painted ſhadow on a canvaſs, or perhaps a little brazen clock-work is the ſupreme pride of their art, their higheſt excellence and perfection.

Let the atheiſt then exert his utmoſt ſtretch of underſtanding: let him try the force of all his mechanical powers, to compoſe the wing of a butterfly, or the meaneſt feather of a ſparrow: let him labour, and ſweat and faint, and acknowledge his own weakneſs: then let him turn his eye, and look at thoſe wondrous compoſures, his ſon, or his little daughter, and when their infant tongues ſhall inquire of him, and ſay, "Father, who made us?" Let him not dare aſſume the honour of that work to himſelf, but teach the young creatures that there is a God, and fall down on his face, and repent and worſhip.

It was God who ſaid at firſt, "Let the earth bring forth graſs, and the herb yielding ſeed—after his kind—and the living creature after his kind:" and when this was done, then with a creating voice he bid thoſe herbs and thoſe living creatures "be fruitful and multiply" to all future generations. "Great things doth he which we cannot comprehend.—But he ſealeth up the hand of every man, that all men may know his divine work." Gen. i. 11. 25. Job. xxxvii. 5. 7.

SECT.

SECT. II.

The Laws of Nature ſufficient for the Production of Animals and Vegetables.

WILL you ſuppoſe that it derogates from the glory of divine Providence, to repreſent the great engine of this viſible word, as moving onward in its appointed courſe, without the continual interpoſure of his hand? It is granted, indeed, that his hand is ever active in preſerving all the parts of matter, in all their motions, according to theſe uniform laws: but I think it is rather derogatory to his infinite wiſdom, to imagine that he would not make the vegetable and animal, as well as the inanimate world, of ſuch ſorts of workmanſhip, as might regularly move onward in this manner for five or ſix thouſand years, without putting a new hand to it ten thouſand times every hour: I ſay ten thouſand times every hour; for there is not an hour nor a moment paſſes, wherein there are not many millions of plants and animals actually forming in the ſouthern or northern climates.

He that can make a clock, with a great variety of beauties and motions, to go regularly a twelvemonth together, is certainly a ſkilful artiſt; but if he muſt put his own hand to aſſiſt thoſe motions every hour, or elſe the engine will ſtand ſtill, or the wheels move at random, we conceive a much meaner opinion of his performance and his ſkill. On the other hand, how glorious and divine an artificer would he be called that ſhould have made two of theſe pieces of clock-work above five thouſand years ago, and contrived ſuch hidden ſprings and motions within them, that they ſhould have joined together, to perpetuate the ſpecies, and thus continue the ſame ſort of clocks in more than a hundred ſucceſſions down to this day? though each of their ſprings might fail in forty years time, and their motions ceaſe, or their materials decay, yet that by the means of theſe two original engines, there ſhould be engines of the ſame kind multiplied upon the face of the earth, by the ſame rules of motion which the artiſt had eſtabliſhed in the day when he firſt formed them?

Such

Such is the workmanſhip of God; for nature is nothing but his art. Such is the amazing penetration of divine ſkill, ſuch the long reach of his foreſight, who has long ago ſet his inſtruments at work, and guarded againſt all their poſſible deficiencies; who has provided to repleniſh the world with plants and animals to the end of time, by the wondrous contrivance of his creation, and the laws he then ordained.

Thus every whale, eagle and apple-tree, every lion and roſe, fly and worm in our age, are as really the work of God, as the firſt which he made of the kind. It is ſo far from being a derogation to his honour, to perpetuate all the ſpecies by ſuch inſtruments of his agency for many ages, that it rather aggrandizes the character of the Creator, and gives new luſtre to Divine Wiſdom: for if any thing can be ſaid to be eaſier or harder in this ſort of almighty work, we may ſuppoſe it a more glorious difficulty for a God to employ a ſparrow or an oyſter, to make a ſparrow or an oyſter, than to make one immediately with his own hand. Perhaps there is not a waſp or a butterfly now in the world, but has gone through almoſt ſix thouſand anceſtors, and yet the work of the laſt parent is exquiſitely perfect in ſhape, in colour, and in every perfection of beauty: but it is all owing to the firſt cauſe.

This is wiſdom becoming a God, and demands an eternal tribute of wonder and worſhip.

SECT. III.

Of the Nouriſhment and Growth of Plants.

IN the beginning of time and nature, at the command of God, the earth brought forth plants and herbs, and four-footed animals in their various kinds; but the birds of the air, as well as the fiſhes, were produced by the ſame command out of the waters. This was intimated in a former ſection. The water and the earth were the firſt appointed mothers, if I may ſo expreſs it, of all the animal and vegetable creation. Since that time they ceaſe to be parents indeed, but they are the

the common nurſes of all that breathe, and of all that grow. Nor is the wiſdom of God much leſs conſpicuous in conſtituting two ſuch plain and ſimple beings as the earth and water, to be the ſprings of nouriſhment and growth to ſuch an innumerable variety of creatures, than it was in the formation of them out of two ſuch materials. Is it not counted an admirable piece of divine contrivance and wiſdom, that the ſingle principle of gravitation ſhould be employed by the Creator, to anſwer ſo many millions of purpoſes among the heavenly bodies in their regular revolutions as well as among the inhabitants, and the furniture of this earthly globe where we dwell? And may it not be eſteemed as aſtoniſhing an effect of the ſame ſupreme wiſdom, that two ſuch ſimple things as water and earth ſhould be the common materials out of which all the ſtanding ornaments, the vegetable beauties, and the moving inhabitants, of this our world, whether flying or creeping, walking, or ſwimming, ſhould receive their continual ſuſtenance, and their increaſe?

Let us firſt conſider this as it relates to the vegetable part of the creation. What a profuſion of beauty and fragrancy, of ſhapes and colours, of ſmells and taſtes, is ſcattered among the herbs and flowers of the ground, among the ſhrubs, the trees, and the fruits of the field! Colouring in its original glory and perfection triumphs here; red, yellow, green, blue, purple, with vaſtly more diverſities than the rainbow ever knew, or the priſm can repreſent, are diſtributed among the flowers and bloſſoms. And what variety of taſtes, both original and compounded, of ſweet, bitter, ſharp, with a thouſand nameleſs flavours, are found among the herbs of the garden? What an amazing difference of ſhapes and ſizes appears amongſt the trees of the field and foreſt in their branches and their leaves? And what a luxurious and elegant diſtinction in their ſeveral fruits? How very numerous are their diſtinct properties, and their uſes in human life? And yet theſe two common elements, earth and water, are the only materials out of which they are all compoſed, from the beginning to the end of nature and time!

Let the gardener dreſs for himſelf one field of freſh earth, and make it as uniform as he can; then let him

plant

plant therein all the varieties of the vegetable world, in their roots or in their ſeeds, as he ſhall think moſt proper: yet out of this common earth, under the droppings of common water from heaven, every one of theſe plants ſhall be nouriſhed, and grow up in its proper form; all the infinite diverſity of ſhapes and ſizes, colours, taſtes and ſmells, which conſtitute and adorn the vegetable world, (would the climate permit) might be produced out of the ſame clods. What rich and ſurpriſing wiſdom appears in that Almighty Operator, who out of the ſame matter ſhall perfume the boſom of the roſe, and give the garlic its offenſive and nauſeous powers? Who from the ſame ſpot of ground, ſhall raiſe liquorice and the wormwood, and dreſs the cheek of the tulip in all its glowing beauties? What a ſurpriſe, to ſee the ſame ſeed furniſh the pomegranate and the orange-tree with the juicy fruit, and the ſtalks of corn with their dry and huſky grains? To obſerve the oak raiſed from a little acorn, into its ſtately growth and ſolid timber, out of the ſame bed of earth that ſent up the vine with ſuch ſoft and feeble limbs? What a natural kind of prodigy is it, that chilling and burning vegetables ſhould ariſe out of the ſame ſpot? That the fever and the frenzy ſhould ſtart up from the ſame bed, where the palſy and the lethargy lie dormant in their ſeeds? Is it not exceeding ſtrange, that healthful and poiſonous juices ſhould riſe up in their proper plants out of the ſame common glebe, and that life and death ſhould grow and thrive within an inch of each other?

What wondrous and inimitable ſkill muſt be attributed to that Supreme Power, that Firſt Cauſe, who can ſo infinitely diverſify effects, where the ſervile ſecond cauſe is always the ſame?

It is not for me in this place to enter into a long detail of Philoſophy, and ſhew how the minute fibres and tubes of the different ſeeds and roots of vegetables take hold of, attract, and receive the little particles of earth and water proper for their own growth; how they form them at firſt into their own ſhapes, and ſend them up aſpiring above ground by degrees, and mould them ſo as to frame the ſtalks, the branches, the leaves, and the buds of every flower, herb and tree. But I

preſume

preſume the world is too weary of ſubſtantial forms, and plaſtic powers, to be perſuaded that theſe mere creatures of fancy ſhould be the operators in this wondrous work. It is much more honourable to attribute all to the deſign and fore-thought of God, who formed the firſt vegetables in ſuch a manner, and appointed their little parts to ferment under the warm ſun-beams, according to ſuch eſtabliſhed laws of motion, as to mould the atoms of earth and water which were near them into their own figure, to make them grow up into trunk and branches, and which every night ſhould harden into firmneſs and ſtability; and again, to mould new atoms of the ſame element into leaves and bloom, fruit and ſeed, which laſt being dropt into the earth, ſhould produce new plants of the ſame likeneſs to the end of the world.

It is eaſier for the ſons of men to ſtand and wonder, and adore God the Creator, than to imitate, or even to deſcribe his admirable works. In the beſt of their deſcriptions and their imitations of this divine artiſt, they do but chatter like Hottentots, and paint like Goths and Vandals.

SECT. IV.

Of the Nouriſhment and Growth of Animals.

LET us proceed in the next place to ſurvey new wonders. All the animals of the creation as well as the plants, have their original nouriſhment from theſe ſimple materials, earth and water. For all the animal beings which do not live upon other animals, or the produce of them, take ſome of the vegetables for their food; and thus the brutes of prey are originally indebted to the plants and herbs, i. e. to the earth for their ſupport, and their drink is the watry element. That all fleſh is graſs, is true, in the literal, as well as the metaphorical ſenſe. Does the lion eat the fleſh of the lamb? Doth the lamb ſuck the milk of the ewe? But the ewe is nouriſhed by the graſs of the field. Does the kite devour the chicken, and the chicken the little caterpillars or inſects of the Spring? But theſe inſects are ever feeding on the tender plants, and the green

products

products of the ground. The earth moistened with water is the common nurse of all. Even the fishes of the sea are nourished with vegetables that spring up there, or by preying on lesser fishes which feed on these vegetables.

But let us give our meditations a loose on this entertaining subject, and we shall find numerous instances of wonder in this scene of Divine contrivance.

1. What very different animals are nourished by the same vegetable food! The self-same herbage or fruits of the earth by the divine laws of nature and providence, are converted into animated bodies of very different kinds. Could you imagine that half the fowls of the air, as different as they are from the crow to the tit-mouse, should derive their flesh and blood from the productions of the same tree, where the swine watch under the boughs of it, and are nourished by the fruit? Nor need I stay to take notice what numerous insects find their nests and their food all the summer-season from the same apples or apricots, plumbs or cherries, which feed hogs or crows, and a hundred small birds. Would you think that the black and the brindled kine, with the horses both grey and bay, should clothe themselves with their hairy skins of so various colours, out of the same green pasture where the sheep feed, and cover themselves with their white and woolly fleece? And at the same time the goose is cropping part of the grass to nourish its own flesh, and to array itself with down and feathers. Strange and stupendous texture of the bodies of these creatures, that should convert the common green herbage of the field, into their different natures, and their more different clothing! But this leads me to another remark.

2. What exceeding great diversity is found in the several parts, limbs, and coverings even of the same creature? An animated body is made up of flesh and blood, bones and membranes, long, hollow tubes, with a variety of liquors contained in them, together with many strings and tendons, and a thousand other things which escape the naked sight, and for which anatomy has hardly found a name: yet the very same food is,

by

by the wondrous ſkill and appointment of the God of Nature, formed into all theſe amazing differences. Let us take an ox to pieces, and ſurvey the wondrous compoſition. Beſides the fleſh of this huge living ſtructure, and the bones on which it is built, what variety of tender coats and humours belong to that admirable organ the eye? How ſolid and hard are the teeth which grind the food? How firm the general ligaments that tie the joints of that creature together? What horny hoofs are his ſupport, and with what different ſort of horny weapons has nature furniſhed his forehead? Yet they are all framed of the ſame graſſy materials: the calf grazes upon the verdant paſture, and all its limbs and powers grow up out of that food to the ſize and firmneſs of an ox. Can it be ſuppoſed, that all theſe corpuſcles, of which the ſeveral inward and outward parts of the brute are compoſed, are actually found in their different and proper forms in the vegetable food? Does every ſpire of graſs actually contain the ſpecific parts of the horn and the hoof, the teeth and the tendons, the glands and membranes, the humours and coats of the eye, the liquids and ſolids, with all their innumerable varieties in their proper diſtinct forms? This is a moſt unreaſonable ſuppoſition. No, it is the wiſdom of the God of Nature that diſtributes this uniform food in the ſeveral parts of the animal by his appointed laws, and gives proper nouriſhment to each of them.

Again 3. If the food of which one ſingle animal partakes, be never ſo various and different, yet the ſame laws of motion, which God has ordained in the animal world, convert them all to the ſame purpoſes of nouriſhment for that creature. Behold the little bee gathering its honey from a thouſand flowers, and laying up the precious ſtore for its winter food! Mark how the crow preys upon a carcaſe: anon it crops a cherry from the tree, and both are changed into the fleſh and feathers of a crow. Obſerve the kine in the meadows, feeding on a hundred varieties of herbs and flowers; yet all the different parts of their bodies are nouriſhed thereby in a proper manner: every flower in the field is made uſe of to increaſe the fleſh of the heifer, and to

make

make food for men: and out of all these varieties, there is a noble milky juice flowing to the udder, which provides nourishment for young children.

So near a-kin is man, the lord of the creation, in respect of his body, to the brutes that are his slaves, that the very same food will compose the flesh of both, and make them grow up to their appointed stature. This is evident, beyond doubt, in daily experiments. The same bread-corn which we eat at our tables will give rich support to sparrows and pigeons, to the turkey, and the duck, and all the fowls of the yard: the mouse steals it and feeds on it in his dark retirements; while the hog in the sty and the horse in the manger, would be glad to partake of it. When the poor cottager has nursed up a couple of geese, the fox seizes one of them for the support of her cubs, and perhaps the table of the landlord is furnished with the other to regale his friends. Nor is it an uncommon thing to see the favourite lap-dag fed out of the same bowl of milk, which is prepared for the heir of a wealthy family, but which nature had originally designed to nourish a calf. The same milky material will feed calves, lap-dogs and human bodies.

How various are our dishes at an entertainment? How has luxury even tired itself in the invention of meats and drinks in an excessive and endless variety? Yet when they pass into the common boiler of the stomach, and are carried thence through the intestines, there is a white juice strained out of the strange mixture called chyle, which from the lacteal vessels is converted into the blood, and by the laws of nature is conveyed into the same crimson liquor. This being distributed through all the body by the arteries, is farther strained again through proper vessels, and becomes the spring of nourishment to every different part of the animal. Thus the God of Nature has ordained, that how diverse soever our meats are, they shall first be reduced to an uniform milky liquid, that by new contrivances, and divine art it may be again diversified into flesh and bones, nerves and membranes.

How conspicuous, and yet how admirable are the operations of Divine Wisdom in this single instance of nourishment! But it is no wonder that a God who

could

could create ſuch aſtoniſhing and exquiſite pieces of machinery, as plants and animals, could preſcribe ſuch laws to matter and motion, as to nouriſh and preſerve the individuals, as well as to propagate the ſpecies, through all ages to the end of time.

SECT. V.

The ſimilar Operations of Plants and Animals.

IT is with admiration and pleaſure we take notice of the regular actions of animals even in their earlieſt hours of life, before they can poſſibly be taught any thing by remark or imitation. Obſerve the young ſparrows in the neſt: ſee how the little, naked creatures open their mouths wide to their dam, as though they were ſenſible of their dependance on her care for food and nouriſhment. But the chicken juſt releaſed from the priſon of the ſhell, can pick up its food with its own bill, and therefore it doth not open its mouth to beg food of the hen that hatched it. Yet the chicken ſeems to ſhew its dependance too: for when the firſt danger appears, you ſee it run and fly to the wing of its dam for protection; as if it knew, that though it could feed itſelf, yet it was not able to defend itſelf, but muſt truſt to the better ſecurity of a parent's wing.

We admire theſe little creatures, and their remarkable ſagacity; we are ſurpriſed to find that they diſtinguiſh ſo happily, and purſue their proper intereſt; that they are ſo ſoon acquainted with their abilities and their wants, and come to uſe their underſtanding ſo very early; for it is evident, that the mere faculty of ſenſe, that is, the paſſive reception of images or ideas, can never be ſufficient to account for theſe wondrous imitations of reaſon; ſenſe has nothing to do but with the preſent impreſſion, and includes no reflection or proſpect of the paſt or the future, no contrivance of means to an end, nor any action in order to obtain it.

But what ſhall we ſay, or how ſhall we account for it, if we are told there are inſtances almoſt as admirable as theſe to be found in the vegetable world, where we never ſuſpect ſenſe or reaſon? The vine, as though

it

it were ſenſible of its own weakneſs, thruſts forth its long tendrils, which curl round the branches of any ſtronger tree that ſtands near, and thus it hangs its weighty cluſters upon the arms of the elm that ſupport it. Nay, every cluſter has a tendril belonging to it, and if any ſtronger twig than its own be within its reach, it hangs itſelf there by this tendril for ſupport. The hop and the lupin, or French bean, as though they knew they could not ſtand by themſelves, find another way to raiſe their heads on high; they twine the whole length of their bodies round the poles or the rods which are planted near them; and thus their growth and their fruit are upheld from rotting upon the ground. The ivy, for the ſame reaſon, but by another contrivance, climbs up the oak, and ſticks cloſe to its ſides; and the feeble plant which we vulgarly call the creeper, that can hardly raiſe itſelf three feet high alone, thruſts out its claws at proper diſtances, fixes them faſt in the neighbouring wall or building, and mounts by this means to the tops of the higheſt houſes. What variety of artifice is found here among theſe feeble vegetables to ſupport themſelves!

Yet we believe theſe plants have no underſtanding, and mankind are all agreed they have no ſuch thing as ſenſe belonging to them; and we immediately recur to the wiſdom of God the Creator, and aſcribe the contrivance and the honour of it to him alone. It was he (we ſay) who gave the vine its curling tendrils, and the creeper its hooky claws: it was he inſtructed the one to bind itſelf with natural winding cords to the boughs of a ſtronger tree, and he taught the other as it were, to nail itſelf againſt the wall. It was he ſhewed the ivy to aſcend ſtraight up the oak; and the hop and the lupin, in long ſpiral lines, to twine round their proper ſupporters.

Let us inquire now, What do we mean by ſuch expreſſions as theſe? Truly nothing but this; that God formed the natures of theſe vegetables in ſuch a manner, as that by certain and appointed rules of mechanical motion, they ſhould grow up and move their bodies and their branches ſo, as to raiſe and to uphold themſelves and their fruit. Thus the wiſdom of God, the great Artificer, is glorified in the vegetable world.

And

And why ſhould we not give God the Creator the ſame honour of his wiſdom in the animal world alſo? Why may not we ſuppoſe that he has formed the bodies of brute creatures, and all their inward ſprings of motion, with ſuch exquiſite art, as even in their youngeſt hours, without reaſoning and without imitation, to purſue thoſe methods as regularly which are neceſſary for their life and their defence, by the ſame laws of motion and the ſame unthinking powers? This is nature, when God has appointed it. This ſeems to be the true idea, and the cleareſt explication of that obſcure word, Inſtinct.

If we allow theſe young animals to perform all their affairs by their own contrivance and ſagacity, why do not we aſcribe the ſame ſagacity and artifice to vines and ivy, that we do to young ſparrows or chickens? The motions of the plants are ſlower indeed, but as regular and rational as thoſe of the animals; they ſhew as much deſign and contrivance, and are as neceſſary and proper to attain their end.

Beſides, if we imagine theſe little young birds to practiſe their different forms of motion for their nouriſhment or defence by any ſprings of reaſon, meaning, or deſign in themſelves, do we not aſcribe underſtanding to them a little too ſoon, and confeſs their knowledge is much ſuperior to our own, and their reaſon of more early growth? Do we not make men, or rather angels of them, inſtead of brute creatures? But if we ſuppoſe them to be actuated by the peculiar laws of animal motion, which God the Creator, by a long foreſight has eſtabliſhed amongſt his works, we give him the honour of that early and ſuperior reaſon, and we adore the Divine Artificer. "Pſalm cxlv. 10. All thy works ſhall praiſe thee, O Lord."

But we are loſt among theſe wonders of thy wiſdom! We are ignorant of thy divine and inimitable contrivances! What ſhall we ſay to thee, thou All-wiſe, Creating Power! Thy works ſurpriſe us: the plants and the brutes puzzle and confound our reaſonings: we gaze at thy workmanſhip with ſacred amazement: thy ways in the kingdom of nature are untraceable, and thy wonders paſt finding out.

But

But what will ſome readers ſay when they peruſe theſe diſcourſes? Are plants and brutes ſo very near a-kin to each other? Creatures which we have always diſtinguiſhed into the ſenſible and the ſenſeleſs? Have birds and beaſts no more perception or feeling, knowledge or conſciouſneſs, underſtanding or will than the herbs the trees and the flowers? Is the graſs of the field as wiſe a thing as the animal which eats it? Excuſe me here, my friends: I dare aſſert no ſuch paradoxes. What if ſome of the early actions of brute creatures are merely the effects of ſuch machinery and inſtinct as I before deſcribed? It does not follow thence, that all the actions and operations of their lives muſt be aſcribed to ſuch a mechanical principle. Even in human nature, where there is an undoubted principle of ſenſe and reaſoning, there are ſome early actions which ſeem to be the proper effects of ſuch inſtinct or mechaniſm, and are owing to the wondrous divine artifice in the contrivance of their animal bodies, and not to any exerciſe of their own reaſoning powers. How doth the infant hunt after the breaſt, and take it into its mouth, moving the lips, tongue, and palate in the moſt proper forms for ſucking in the milk to nouriſh it? How does it readily ſhut the eyes, to cover them from any danger near? How does it raise its cries and wailing aloud for help when it is hurt? Theſe are certainly the effects of inſtinct in their outward members, as much as the circulation of their blood and the digeſtion of their food in their bowels and inward parts.

It is certain, there are ſeveral operations in the lives of brute creatures, which ſeem to be more perfect imitations of reaſon, and bid fairer for the real effect of a reaſoning principle within them, than theſe early actions which I have mentioned. What ſtrange ſubtilty and contrivance ſeem to be found in the actions of dogs and foxes? What artifices appear to be uſed both by birds and beaſts of prey, in order to ſeize the animals which were appointed for their food, as well as in the weaker creatures to avoid and eſcape the devourer? How few are there of the paſſions, as well as the appetites of human nature, which are not found among ſeveral of the brute creatures? What reſentment and

rage do they diſcover? What jealouſy and fear, what hope and deſire, what wondrous inſtances of love and joy, of gratitude and revenge? What amazing appearances of this nature are obſerved in birds and beaſts of the more docile and domeſtic kind? Such as puzzle the wiſeſt of philoſophers to give a plain, fair and ſatisfactory account how all theſe things can be performed by mechaniſm, or the mere laws of matter and motion? But how many actions ſoever may be performed by brute creatures, without any principle of ſenſe or conſciouſneſs, reaſon or reflexion, yet theſe things can never be applied to human nature. It can never be ſaid, that man may be an engine too, that man may be only a finer ſort of machine, without a rational and immortal ſpirit. And the reaſon is this. Each of us feel and are conſcious within ourſelves, that we think, that we reaſon, that we reflect, that we contrive and deſign, that we judge and chuſe with freedom, and determine our own actions: we can have no ſtronger principle of aſſent to any thing than preſent, immediate, intellectual conſciouſneſs. If I am aſſured of the truth of any inference whatſoever, it is becauſe I am ſure of my conſciouſneſs of the premiſes and of my conſciouſneſs that I derive this inference from them. My conſciouſneſs of theſe premiſes therefore is a prior ground of aſſurance, and the foundation of all my certainty of the inferences. Let a thouſand reaſons therefore be laid before me, to prove that I am nothing but an engine, my own inward preſent conſciouſneſs of this propoſition, that I have thoughts, that I have reaſoning powers, and that I have a will and free choice, is a full evidence to me that theſe are falſe reaſonings, and deceitful arguments; I know and am aſſured, by what I feel every moment, that I have a ſpirit within me capable of knowing God, and of honouring or diſhonouring my Maker, of chuſing good or evil, of practiſing vice or virtue, and that I hereby am bound to approve myſelf to the Almighty Being that made and governs me, who will reward me in ſome future ſtate or other, according to my behaviour in this.

And as I can certainly determine this truth, with regard to my own nature, ſo when I ſee creatures round

about

about me of the very ſame ſpecies with myſelf, I juſtly infer the ſame truth concerning them alſo: I conclude with aſſurance, that they are not mere engines, but have ſuch reaſonable and immortal ſpirits in them, as I find in myſelf. It is this inference of ſimilar and equal cauſes from ſimilar and equal effects that makes a great part of the ſcience of mankind.

Beſides, I daily hear men diſcourſing with me on any ſubject, and giving as regular and reaſonable anſwers to my inquiries, as I do to theirs: I feel within myſelf, it is impoſſible for me to do this without thinking, without the careful exerciſe of my intellectual and reaſoning faculties, ſuperior to all powers of mechaniſm; and thence I infer, it is as impoſſible for them to practiſe the ſame diſcourſe or converſation, without the powers of a rational and intelligent ſpirit, which in its own nature is neither material nor mortal.

Let the queſtion therefore which relates to brute creatures be determined to any ſide, it does not at all affect the nature, the reaſon, or the religion of mankind. It is beyond all doubt, that man is a creature which has an intelligent mind to govern the machine of his body; that man has knowledge, and judgment, and free choice; and unleſs he approve his conduct to the eyes of his Creator and his Judge, in this ſtate of mortality and trial, he expoſes himſelf to the juſt vengeance of God in his future and immortal ſtate.

It is certain, that the All-wiſe and All-righteous Governor of intelligent creatures, will not appoint the very ſame fate and period to the pious and the profane; neither his wiſdom, his equity, nor his goodneſs, will ſuffer him to deal out the ſame bleſſings and the ſame events in every ſtate of exiſtence, to thoſe who have loved him with all their ſouls, and thoſe who have hated and blaſphemed his name. It is the glory and the intent of the Supreme Ruler of the univerſe, to make a conſpicuous and awful diſtinction in one world or another, between thoſe who have endeavoured to ſerve him, and to render his majeſty honourable among men, and thoſe who have impiouſly abuſed all his favours, ridiculed his thunder, and robbed him of his choiceſt honours. But if philoſophy ſhould fail us here, if it were poſſible for creatures of ſuch different characters

to have nothing in their own natures which was immortal, yet it is a very reaſonable thing, that the great Judge of all ſhould prolong their beings beyond this mortal ſtate, that the ſons of vice might not go triumphant off the ſtage of exiſtence, and that the men of virtue might not be always oppreſſed, nor come to a period of their being, without ſome teſtimony of the approbation of the God that made them.

CHAP. III.

Of Metals, Minerals, and other Foſſils.

1. *The Variety of Foſſils.*
2. *The general Properties of Metals.*
3. *Of the Nutrition and Generation of Metals.*
4. *Of Gold, Silver, Platina, Copper, Iron, Tin, Lead.*
5. *Of Steel.*
6. *Of Quickſilver.*
7. *Of Mines.*
8. *Of Mundic.*
9. *Of the Fiſſures of the Earth.*
10. *Of Salts.*
11. *Of Stones.*
12. *Of petrifying Springs.*
13. *Of Copper Springs.*
14. *Of Lime.*
15. *Of precious Stones.*
16. *Of the Loadſtone.*
17. *Of inflammable Foſſils.*
18. *Of Amber.*
19. *Of Linum Aſbeſtum.*

1. AMONG the bodies that remain to be conſidered, thoſe which ſeem to bear the neareſt reſemblance to plants, are foſſils, comprehending under the name, all bodies that are dug out of the earth. Theſe have frequently been, for order's ſake, divided into three claſſes, ſuch as are capable of liquefaction; ſuch as are reducible to a calx; and ſuch as are inflammable.

mable. Of the firſt claſs are metals, gold, ſilver, platina, copper, iron, tin, lead, quickſilver. However theſe differ in other reſpects, they all agree in the following particulars. That they are heavier than any other bodies yet known; that they are malleable; and that they are capable of liquefaction.

2. It is not improbably ſuppoſed, all metals conſiſt of particles ſo heavy, that they cannot be wholly torn aſunder or diſſipated by fire, or put into ſo rapid a motion as to inflame. It only ſeparates them ſo far as not to reſiſt a hard body, which is what we term liquefaction. Their malleableneſs, or bearing to be wrought by the hammer, may ſpring from the figure of their parts, perhaps oblong or ſquare, which may occaſion their cohering ſo ſtrongly, as not eaſily to be ſeparated. And it is probable the pores either of their conſtituent particles, or of the whole maſs, are few and ſmall, which may account for their being ſo much heavier than any other known bodies.

This is the radical character of metals. The weight of gold to that of glaſs is as nine to one; and the weight of tin, the lighteſt of all metals, is to that of gold as ſeven to nineteen: which conſiderably ſurpaſſes the weight of all ſtones and other the moſt ſolid bodies. Nor is there any body in nature but a metal, that is one third of the weight of gold.

The ſpecific weight of the ſeveral metals, and of the granite water and air, ſtands thus:

Gold	19636	Iron	7852
Quickſilver	14019	Tin	7321
Lead	11345	Granite	3978
Silver	10535	Water	1000
Copper	8843	Air	$\frac{3}{11}$

3. The nutrition of metals ſeems to conſiſt only in the accretion of homogeneous parts, which is not improbably ſuppoſed to continue, while they lie in their native bed. Many ſuppoſe they have lain there ever ſince the flood, if not ever ſince the creation. Whether they have or not, they ſeem to grow as long as they remain therein. And after theſe beds have been emptied

emptied by miners, in time they recruit again. Yea, the earth, or ore of allum will recruit again above ground, if it be expoſed to the open air. And ſo in the foreſt of Deane the beſt iron, and in the greateſt quantities, is found in the old cinders melted over again.

However, it has long been diſputed, whether metals are generated, or were all originally produced at the creation: and whether there be any general ſeeds of metals, as ſome ſuppoſe antimony to be. This is indeed a foſſil of a very peculiar nature. It is a kind of undetermined, metallic ſubſtance, mixed with ſtony and ſulphureous particles, ſo that it is hard to reduce it to any claſs. It is found in mines of all metals, but chiefly in ſilver or lead mines. That in gold mines is counted the beſt. It has alſo its own peculiar mines. It lies in clods of ſeveral ſizes, nearly reſembling black lead, but is full of ſmall ſhining threads, like needles, brittle as glaſs. It melts in the fire, though with ſome difficulty. Its uſes are very numerous. It is a medicine of ſovereign uſe in many caſes, when warily and properly adminiſtered. It is a common ingredient in burning concaves, ſerving to give the compoſition a finer texture. It makes a part in bell-metal, in order to render the ſound more clear. It is mingled with tin, to make it more hard, as well as of a brighter colour, and with lead, in caſting of printers' letters, to render them more ſmooth or firm. It is alſo a general help in caſting of metals, and eſpecially in caſting cannon-balls.

4. Gold is either found in ſmall grains in the ſand of rivers, (formerly in ſeveral of the rivers of Europe) or is dug out of the earth, in ſmall pieces of a tolerable purity. Sometimes it is alſo found like the ore of other metals, in a maſs of earth, ſtone, or ſulphur. In this ſtate it is of all colours, red, white, blackiſh, making no oſtentation of its real value.

The chief properties of gold are, 1. It is the heavieſt, though not the hardeſt of bodies. 2. It is the moſt ductile and malleable of all metals, of which gold-beaters and wire-drawers give us an abundant proof. But this depends altogether (incomprehenſible as it is)

on

on its being free from ſulphur. For mix but one grain of ſulphur with a thouſand of gold, and it is malleable no longer. 3. It is more fixed in the fire than any other metal. Lay a quantity of gold two months in the intenſeſt heat, and when it is taken out, there is no ſenſible diminution of its weight And yet in the focus of a large burning glaſs, it volatilizes and evaporates. Yea, many thouſands of moidores were wholly conſumed, others half, or a quarter conſumed, by the flames which broke out of the earth, during the late earthquake at Liſbon. Gold may likewiſe by a glaſs be fuſed into a ſort of calx, and then vitrified. But if the ſame be fuſed again with greaſe, it is reſtored into gold. 4. It is diſſolvable by no menſtruum known, but aqua regia and mercury. The baſis of aqua regia is ſea-ſalt, the only ſalt which has any effect on gold. But this has its effect, however applied, whether in a fluid or ſolid form. 5. It readily and ſpontaneouſly attracts and abſorbs mercury. But as ſoon as the mercury enters it, the gold becomes ſoft like paſte. 6. It withſtands the violence both of lead and antimony. All metals but gold and ſilver, melted with lead, periſh with it and evaporate: and all but gold, if melted with antimony. Thus melt gold, ſilver, copper and tin with antimony, and all the reſt riſe to the top, and are blown off with bellows, but the gold remains behind. Hence antimony is uſed as the teſt of gold.

The malleableneſs or ductility of gold is beyond all imagination. By exact weighing and computation it has been found, that there are gold leaves, which in ſome parts of them are ſcarce 350000th part of an inch thick. And yet this is a notable thickneſs in compariſon of that of the gold ſpun on ſilk in gold thread. It has been proved, that the breadth of theſe gold plates is only the 96th part of an inch, and their thickneſs the 3072d: ſo that an ounce of gold is here extended to a ſurface of 1190 ſquare feet.

How thin muſt it be when thus extended! In ſome parts it has been computed, its thickneſs is only the 3,150,000th part of an inch! And yet with this amazing thinneſs, it is ſtill a perfect cover for the ſilver: nor can the beſt eye, or even the beſt microſcope diſcern

the

the leaſt chaſm or diſcontinuity. Nay, there is not an aperture to admit alcohol of wine, one of the ſubtleſt fluids in nature: no, nor light itſelf. So cloſely connected are the particles, notwithſtanding their inconceivable thinneſs.

Silver approaches the neareſt to gold in ductility and reſiſting fire. Like the ore of all other metals, it is found in the earth, under different forms and colours. But it uſually affects ſomewhat of a pointed regular form like cryſtals. It is never found in ſand or grains, as native gold is. It is ſometimes aſh-coloured, ſometimes ſpotted with red and blue, ſometimes of changeable colours, many times almoſt black.

Although the hiſtory of foſſils has been diligently cultivated, eſpecially by the moderns, yet it muſt be owned, that amidſt the vaſt variety of them, there is ſtill room for new inquiries. No wonder therefore, that among the great variety of ſalts, ores and other concretes, new mixtures ſhould daily be diſcovered. But that among bodies ſo ſimple as metals, any ſhould ſtill remain unknown, will appear extraordinary.

Yet ſo it is: there has been diſcovered in New Spain, an original metal between gold and ſilver. The Spaniards call it platina, from the reſemblance in colour which it bears to ſilver. It is of an uniform texture, bright and ſhining. It takes a fine poliſh, and does not tarniſh nor ruſt. It is very hard and compact, but extremely brittle, and malleable but in a ſmall degree.

It is found chiefly in ſmall grains, yet not pure, but mixed with a ſhining black ſand. There are likewiſe uſually mixed with it, a few ſhining particles of a golden colour.

When expoſed by itſelf to the fire, it is extremely hard to melt. It has been kept for two hours in an air furnace, in a heat that would melt caſt iron in fifteen minutes, without being either melted or waſted. But when expoſed to a proper heat with gold, ſilver, copper, lead, or tin, it readily melts and incorporates with them. Having been kept in an aſſay-furnace with lead for three hours, till all the lead was wrought off,

it

it was found remaining at the bottom, without having ſuffered any alteration or diminution. A piece of it was put into ſtrong aquafortis, and kept in a ſand heat for twelve hours, yet when taken out, it was no ways corroded, and was of the ſame weight as when put in. It has been ſaid to be heavier than gold: but that is a miſtake. Its ſpecific gravity is to that of water, as fifteen to one. Yet an equal mixture of gold and platina, was near as heavy as gold itſelf, being to water as nineteen to one. It appears then, that no known body comes ſo near gold in fixedneſs and ſolidity If it could be made as ductile as gold, it would not eaſily be diſtinguiſhed from it.

Platina is likewiſe found in large, hard maſſes: theſe maſſes are with great labour, reduced into ſmall grains, which are afterwards ground with mercury to extract the gold; and it is not to be brought into fuſion by the greateſt degree of fire procurable in the ordinary furnaces. It entirely reſiſts the vitriolic acid, which diſſolves or corrodes every other known metallic body except gold. Nay, it reſiſts the marine fumes, and the regal cement, ſo called, from its being ſuppoſed to purify gold from all heterogeneous metallic matters. It alſo reſiſts the force of the vitriolic and nitrous acids, though applied in ſuch a manner as to be capable of perfectly diſſolving all other known metallic bodies. It follows from other experiments, that platina contains no gold; for it cannot, any more than the common metallic ſubſtances, prevent a ſmall portion of gold mixed with it from being diſcoverable. It farther appears, that platina, like gold, is not acted on by the ſimple acids which diſſolve every metallic body beſides: that aquæ regiæ, the ſolvents of gold, prove menſtrua for platina; and that conſequently the common methods for aſſaying or purifying gold by aquafortis, aquæ regiæ, or the regal cement, can no longer be depended on: that it differs from gold, in giving no ſtain to the ſolid parts of animals, not ſtriking a purple colour with tin, not being revived from its ſolutions by inflammable ſpirits, not being totally precipitable by alcaline ſalts; that in certain circumſtances it throws out gold from its ſolutions; that theſe properties afford means of diſtinguiſhing a ſmall portion

of gold mixed with a large one of platina, or a ſmall portion of platina with a large one of gold; and that platina contains no gold, excepting the few particles diſtinguiſhed by the eye. That platina is precipitated from its ſolutions by the vitriolic acid, and by the metallic ſubſtances, which precipitate gold, though ſcarce totally by any: and that its precipitates reſiſt vitrification, and this perhaps in a more perfect manner than precipitates of gold itſelf. It is therefore a ſimple metal of a particular kind, eſſentially diſtinct from all thoſe hitherto known, though poſſeſſed of ſome properties generally ſuppoſed peculiar to gold. Many of its characters have been already pointed out; others reſult from combining it with the ſeveral metals, with each of which, notwithſtanding its reſiſtance to the moſt intenſe fires by itſelf, or with unmetallic additions, it melts perfectly; occaſioning remarkable alterations in their colours, texture, and hardneſs. It melts with equal its weight of each of the metals, with one more readily than with another. With ſome it becomes fluid, in a moderate fire; but a ſtrong one is requiſite for its perfect ſolution. Compoſitions of ſilver, copper, lead, with about one third their weight of platina, which had flowed thin enough to run freely in the mould, and appeared to the eye perfectly mixed, on being digeſted in aquafortis till the menſtruum ceaſed to act, left ſeveral grains of platina in their original form. Upon viewing theſe with a microſcope, ſome appeared to ſuffer no alteration; others exhibited an infinite number of minute, bright, globular protuberances, as if they had juſt begun to melt. Platina hardens and ſtiffens all metals; one more than another, lead the moſt. In a moderate quantity it diminiſhes, and in a large one deſtroys the toughneſs of all the malleable metals, but communicates ſome degree of this quality to caſt iron. Tin bears much the leaſt, and gold and ſilver the greateſt quantity, without the loſs of their malleability. A very ſmall portion of platina ſcarce injures the colour of copper and gold: a larger renders both pale. A far leſs quantity has leſs effect on copper than on gold. It debaſes and darkens in proportion to its quantity, the colour of the white metals: that of ſilver much the leaſt,

leaſt, and of lead the moſt. It in good meaſure preſerves iron and copper from tarniſhing; ſcarce alters gold or ſilver in this reſpect: makes tin tarniſh ſoon, and lead exceeding quick.

Copper comes next to ſilver in ductility. Braſs is an artificial metal, compoſed of copper fuſed with lapis caliminaris. Iron is leſs ductile than any of theſe, and contains more droſs.* It likewiſe eaſily ruſts, whereas ſilver ſeldom ruſts, and gold ſeldom either ruſts or cankers. Tin reſembles lead † but is conſiderably harder, and not near ſo heavy. Indeed it ſeems to be a ſort of imperfect metal, generated of two different ſeeds, that of ſilver, and that of lead, which makes it a kind of compound of both. And it is ſometimes found in ſilver mines, ſometimes in lead mines, though it has alſo mines of its own. It is the lighteſt of all metals, very little ductile or elaſtic, but the moſt fuſible of all. It is ſcarce diſſolvable with acids, but eaſily mixes with other metals.

Of all the ſubſtances concurring to form the terreſtrial globe, iron ſeems to have the greateſt ſhare; as it not only abounds in moſt kinds of ſtone, but enters greatly into the compoſition of clay. This may be judged from the ſimilitude of colour between clay and dry iron ore, from the eaſy vitrification of clay, from the reſemblance of vitrified clay to clinkers of iron, from

* The ſpirit of vitriol being mixed with iron, after fermenting, produces a green vitriol like the natural one. But if for ſpirit of vitriol, you uſe oil of vitriol, which is the moſt acid part of that mineral, there happens immediately a ſmall fermentation, which is quickly over. That fermentation begins again in a few days, under the form of a white ſmoke, which riſes to the ſurface, and the whole maſs of iron turns into a very white pap which ſmells like common ſulphur. When the fermentation is over, the iron, inſtead of turning into green vitriol, becomes on a ſudden white vitriol Mean time there is on its ſurface a black duſt, which is has thrown up. It ſeems this would have made it green. For if white vitriol be mingled with this duſt, it acquires a green colour.

† White lead is thin plates of lead diſſolved in vinegar.
Red lead is commonly calcined.
Black lead (very improperly ſo called) is only a chalky kind of earth.

from its deep red colour after calcination, and laſtly, from its yielding pure iron, by being burnt with oil.

Dr. Liſter has ſhewn, that ſtones out of the human bladder being calcined, iron may be extracted from them by a loadſtone. And there is ſcarce any terreſtrial ſubſtance, either in men, brutes, or plants, which after burning doth not exhibit ſome metallic particles. Dr. Bucher ſays, that out of brick-earth, mixed with any fat or oil, and calcined in the fire, he hath produced iron: for it is only the iron that cauſes the redneſs of the bricks: and it can be extracted from them again. Moreover, metals are diſſolved by the ſalts and moiſture in the earth, and ſo mix with the nutritious juices of vegetables; hence it may in ſome reſpects be ſaid, that we eat metals with the greateſt part of our food.

The arbor Martis is a germination of iron, reſembling a natural plant. The manner of its diſcovery was this. One poured oil of Tartar on iron filings, diſſolved in ſpirits of nitre in a glaſs. Preſently the liquor ſwelled much, though with little fermentation, and was no ſooner at reſt, than there aroſe a ſort of branches adhering to the glaſs, which increaſed till they covered it all over. And theſe branches were ſo perfect, that one might even diſcover a kind of leaves and flowers thereon. The experiment has ſince been frequently repeated, and with the ſame ſucceſs.

A friend of mine ſhewed me an experiment of the ſame kind. In a glaſs placed over a moderate fire, there was a continual budding of ſilver, in the form of a branch. When this was clipped off with ſciſſars, and a little crude mercury added, in a ſmall time there aroſe another branch of true ſilver, which had ſucked in and converted into metallic ſprings, a conſiderable portion of the quickſilver. The increment of new ſilver branches ceaſed not, as long as the fire was continued and freſh mercury ſupplied, for the due nutriment of this mineral vegetation. The ingredients were only aquafortis, quickſilver, and a ſmall quantity of ſilver, far leſs than you may reap in a ſmall time from theſe ſilver ſprigs. Yet far more expenſe is blown away in ſmoke, than can be recovered from this ſilver harveſt.

Not

Not much unlike this was an experiment made by a gentleman, who kept in a cabinet ſome piéces of fire-ſtone from a coal-pit, and ſome large pieces of crude alum-ſtone, ſuch as it was when taken out of the rock. After a time both theſe had ſhot out tufts, of long and ſlender fibres: ſome of which were half an inch long, bended and curled like hairs. And as often as theſe tufts were wiped off, they ſprouted out again.

But both of theſe fall ſhort of what is related by a curious naturaliſt. "Having extracted the ſalts out of a quantity of fern-aſhes after the common method, moſt of the water being evaporated, I had ſeveral pounds of ſalt, moſt of which being dried, I expoſed the reſt to the air. Having put it into a large glaſs, I forgot it for five or ſix weeks: looking after it then, I was ſaluted with a pleaſing ſpectacle. The lixivium had depoſited a large portion of ſalt, out of which ſprung at a ſmall diſtance from each other, about forty branches, which exactly reſemble fern, putting out many leaves on each ſide, from one ſtem. They were of different ſizes, but the figures of all were preciſely the ſame. And theſe artificial vegetables, taking care not to ſhake them, I preſerved for many weeks."

And yet the following account is ſtranger ſtill. "I mixed equal parts of Sal Ammoniac and pot-aſhes which were put into a tall glaſs body, with plenty of volatile ſalt ſublimed. I expected no unuſual appearance from this, having often repeated the operation. Being called out juſt as the ſalt began to appear, how was I amazed at my return, to ſee in the glaſs-head a foreſt in perſpective, ſo delineated, as ſcarce to be equalled by the greateſt maſters. They were a repreſentation of firs, pines, and another ſort of tree which I had never ſeen. But of this delightful ſpectacle I was ſoon deprived by the ſublimation of more ſalts.

"The next day I related this to Sir Robert Murray. He told me, one Daviſon, an experienced Chymiſt, at Paris, had frequently ſhewed him in a glaſs a great company of firs and pines, full as lively as any can be painted. But in a little time they diſappeared. He produced them again at pleaſure. But herein his operation differed from mine: the ſubſtance out of which

he

he raiſed thoſe ſhapes was of a more fixed nature; that which afforded mine, was volatile to the higheſt degree. Again, he could conſtantly and regularly produce thoſe beautiful repreſentations: whereas mine unexpectedly appeared; nor have I any hope of ſeeing them again."

Sal Ammoniac is made of the ſoot ariſing from the dung of our four-footed animals, as ſheep, oxen, and camels, ſo long as they feed only on green vegetables. This dung is collected in the four firſt months of the year, when all theſe feed on freſh ſpring graſs. This, in Egypt, is a kind of trefoil or clover. But when the cattle are fed on hay, and the camels on bruiſed date-kernels, their excrements are not fit for this purpoſe.

The nitre of Egypt was well known to the ancients. It is produced in two lakes near Memphis. One of them is four or five leagues long and one league broad: the other, three leagues long, and one and a half broad. In both, the nitre is covered by a foot or two of water. They cut it up with long iron bars, ſharp at the end. And what is taken away, is replaced in one or two years, by new nitre, coming out of the earth.

5. If iron in melting be carefully purged from its droſs, drawn into plates, and plunged red hot into cold water, it grows harder, and is termed ſteel. But it is conſiderably ſoftened again, if it is put into the fire, and afterward left to cool gradually in the air.

6. Quickſilver differs from all metals, in that it is naturally liquid. Its properties are, 1. It is the heavieſt of all bodies, but gold and platina. 2. It is the moſt fluid of all. The particles even of water, do not divide ſo eaſily as thoſe of quick-ſilver: they have hardly any coheſion. 3. Of all bodies it is diviſible into the minuteſt parts. Being on the fire, it reſolves into an almoſt inviſible vapour. But let it be divided ever ſo much, it ſtill retains its nature. For the vapours of diſtilled quickſilver, received in water or on moiſt leather, become pure quickſilver. And if it be mixed with lead or other bodies, in order to be fixed, it is eaſily by fire ſeparated from them again, and reduced to its ancient form. 4. It is extremely volatile,

volatile, being convertible into a fume, even in a ſand-heat. 5. Of all fluids it is in equal circumſtances the coldeſt and the hotteſt. This depends on its weight; for the heat and cold of all bodies, is (cæteris paribus) as their weight. 6. It is diſſolvible by almoſt all acids, but vinegar. And hereby we diſcover, if it be ſophiſticated with lead. Rub it in a mortar with vinegar. If it be mixed with lead it grows ſweetiſh: if with copper it turns greeniſh or bluiſh. If there be no adulteration, the quickſilver and vinegar will both remain as before. 7. It is the moſt ſimple of all bodies, but gold and platina. 8. It has no acidity at all, nor does it corrode any body.

But it may be obſerved of metals in general, there is great uncertainty and inconſtancy in the metallic and mineral kingdoms, both as to colour, figure, and ſituation. A marcaſite, for inſtance, may have the colour of gold and ſilver, and yet afford nothing but a little vitriol and ſulphur: while what is only a pebble in appearance, may contain real gold.

It is common alſo to find the ſame metal ſhot into many different forms, as well as to find different kinds of metal of the ſame form. There is the ſame uncertainty as to their place. Sometimes they are found in the perpendicular fiſſures of the ſtrata, ſometimes interſperſed in the ſubſtance of them; and the ſame metals in ſtrata of very different natures. They are likewiſe frequently intermixed with each other; ſo that we ſeldom find any of them pure and ſimple, but copper and iron, gold and copper, ſilver and lead, tin and lead in one maſs: yea ſometimes all ſix together.

What diſtinguiſhes them from all other bodies, as well as from each other, is their heavineſs: each metal having its peculiar weight, which no art can imitate.

But who can reckon the various ways, wherein metals are uſeful to mankind? Without theſe we could have nothing of culture or civility; no tillage or agriculture; no reaping or mowing, no plowing or digging, no pruning or grafting, no mechanic arts or trades, no veſſels or utenſils of houſhold ſtuff, no convenient houſes or edifices, no ſhipping or navigation. What a barbarous and ſordid life, we muſt neceſſarily

have

have lived, the Indians in the northern parts of America, are a clear demonſtration.

And it is remarkable, that thoſe which are of moſt neceſſary uſe, as iron and lead, are the moſt plentiful. Thoſe which may better be ſpared, are more rare. And by this very circumſtance they are qualified to be made the common meaſure and ſtandard of the value of other commodities, and to ſerve for money, to which uſe they have been employed by all civilized nations in all ages.

All metals are liable to ruſt. Gold itſelf ruſts, if expoſed to the fumes of ſea-ſalt. The great inſtrument in producing ruſt is water : air, only by the water it contains. Hence in dry air metals do not ruſt ; neither, if they are well oiled : water not being able to penetrate oil. Ruſt is only the metal under another form. Accordingly ruſt of copper may be turned into copper again. Iron if not preſerved from the air by paint, will in time turn wholly into ruſt.

7. Mines in general are cavities, within the earth, containing ſubſtances of various kinds. Theſe the miners term loads : if metallic, they are ſaid to be alive ; if not, to be dead bodies. In Cornwall and Devonſhire the loads always run from eaſt to weſt. Mines ſeem to be, or to have been channels of waters within the earth, and have branches opening into them in all directions. Moſt mines have ſtreams running through them : where they have not, probably the water has changed its courſe. The ſprings in theſe parts are always hard, abounding either with ſtony or ſulphureoſaline particles. Theſe particles are either of a vitriolic or an arſenical nature. The firſt concretes into white cubes, reſembling ſilver, the ſecond into yellow ones reſembling gold. Both theſe are by the miners termed mundic.

8. Mundic is variouſly coloured, on the outſide with blue, green, purple, gold, ſilver, braſs and copper-colours. But within it is either of the colour of ſilver, of braſs, or gold-colour, or brown. The other colours are no more than a thin film or ſediment, which water

water variouſly impregnated, depoſits upon the ſurface.

There are few copper loads, if any, but have this ſemi-metal (which is a kind of wild mock-copper) attending upon them. Therefore, in ſearching for copper, it is reckoned a great encouragement to meet with mundic. The mundic does not intimately incorporate itſelf with the ore of copper; for copper in its mineral ſtate, being uſually of a cloſe conſiſtence, repels the mundic, which is therefore eaſily ſeparated from the ore.

Corniſh waters are infected by mundic, more or leſs, according to the quantity which they paſs through, and the diſpoſition of the mundic, either to retain or to communicate the noxious particles of which it conſiſts. Arſenic, ſulphur, vitriol, and mercury are the conſtituents of mundic, yet theſe pernicious ingredients are ſo bridled and detained by their mutual action and reaction, and by mixing with other minerals, that the water is not poiſonous, (generally ſpeaking) even in the mine where it proceeds directly from the mundic.

Mundic reſembles plants, animals, mouldings, carvings, and ſundry more varieties, too numerous to inſert. Shall we attribute this to a plaſtic power ſuperintending the congreſs of foſſils, and ſporting itſelf with ſuch repreſentations? Or ſhall we rather ſay, that the great power which contrived and made all things, needing no delegate, artfully throws the flexile liquid materials of the foſſile kingdom into various figures, to draw the attention of mankind to his works, and thence lead them to the acknowledgement, and adoration of an intelligent Being, inexhauſtibly wiſe, good and glorious? Doubtleſs theſe are the works of that ſame lover of ſhape, colour and uniformity that paints the peacocks's train, that veins the onyx, that ſtreaks the zebra: it is the ſame hand whoſe traces we may diſcover even among the meaneſt and moſt obſcure foſſils. God loves ſymmetry, gracefulneſs, elegance, and variety, and diſtributes them for his complacency as well as glory, limits them not to plants, and animals, and open day light, but like a great maſter habitually imparts them to all his works, though

in the deepeſt ocean, and in the moſt ſecret parts of the earth.

9. Although fiſſures are the natural reſult of a moiſtened and mixed congeries of matter, paſſing by approximation of parts into a ſtate of ſolidity, we are by no means to conclude them uſeleſs, or the works of chance. No, the great Architect, who contrived the whole, determined the ſeveral parts of his ſcheme ſo to operate, as that one uſeful effect ſhould become the beneficial cauſe of another. Hence it happens that matter could not contract itſelf into ſolid large maſſes, without leaving fiſſures between them: and yet the fiſſures are as neceſſary and uſeful as the ſtrata through which they paſs.—Theſe are the drains which carry off the redundant moiſture from the earth, which but for them, would be too full of fens and bogs for animals to live, or plants to thrive on.—Through theſe fiſſures the rain which ſinks beneath the channels of rivers, not having the advantage of that conveyance above ground, returns into the ſea, bringing the ſalts and mineral juices of the earth into the ocean, enabling it to ſupply the firmament with proper and ſufficient moiſture, and preſerving that vaſt body, the ſea, wholeſome, fit for fiſh to live in, and ſailors to navigate.

In theſe fiſſures the ſeveral ingredients which form the richeſt loads, by the continual paſſing of waters, and the menſtrua of metals, are educed out of the adjacent ſtrata, collected and conveniently lodged in a narrow channel, much to the advantage of thoſe who ſearch for and purſue them. For if minerals were more diſperſed, and ſcattered thinly in the body of the ſtrata, the trouble of finding and getting at metals (thoſe neceſſary inſtruments of art and commerce, and the ornaments of life) would be endleſs, and the expenſe of procuring, would exceed the value of the acquiſition: without theſe, neither metals, marbles, ſalts, earths, nor ſtones, could be ſo eaſily or in ſuch plenty, provided, as is neceſſary for the uſe of man.

Earth is certainly the general food and ſtamen of all bodies, yet we know of itſelf it can do nothing: it muſt be connected by a cement, or it cannot form ſtone; it muſt be ſoftened and attenuated by moiſture

and

and warmth, or it cannot enter into the alimentary veſſels of plants and animals. The parts of earth which conſtitute the ſolids of any plants are exceeding fine, and the common maſs in which we plant trees, is for the moſt part gravel, clay, and ſand, which promote vegetation, but are too groſs to enter into, and become the conſtituent parts of them. Water muſt therefore be conſidered as the vehicle of more ſolid nouriſhment, and the parent of the fluids: the earths, ſalts, and oils, are the great inſtruments of the increaſe of ſolids. To trace fertility a little farther: when the earth is ſoftened and diluted heat rarefies and evaporates the mixture; the ſalts contained and diſſolved, are always active and promote motion; the elaſticity of the air quickens and continues it: the oils ſupple the paſſages, of which ſome are fitted to ſecrete, arreſt, and depoſit the nutritious particles as they paſs; ſome adapted (by the ſame ſecret hand, which conducts every part of the operation) to throw off the redundant moiſture by perſpiration: the earthly mixture compoſes the hard and ſolid parts, and the genial, little atmoſphere of every plant gives ſpirit, colour, odour and taſte. Herbs and fruits being thus fed and matured, make the earth they contain better prepared to paſs into the ſtill more curious and highly organized parts of animals. It is eaſy to ſee that this is rather a detail of the ſeveral materials, and well-known inſtruments, conducing to fertility, than the cauſe. Fertility is owing to the concert, fitneſs and agreement of all theſe, with ſome volatile active principle, of which we know nothing at all. But whence that agreement reſults, how the materials ferment, replace, connect, and invigorate one another, how the veſſels chuſe and refuſe, (if I may ſo ſay) in order to produce the fertility deſired, is known only to the infinitely wiſe diſpoſer of all things, ever attentive to the nurture and ſupport of what he has created. But to whatever cauſe the fertility of earth is to be aſſigned, earth it muſt be owned is a moſt fruitful univerſal element. Animals, plants, metals, and ſtones ariſe out of it, and return to it again; there, as it were to receive a new exiſtence, and form new combinations, the ruins and diſſolutions of one ſort affording more and more materials for the production of others.

In

In ſtones and metals, we admire the continuity, hardneſs and luſtre of earth; in plants the rarity, ſoftneſs, colours, and odours: in animals the fleſh, the bone, and an infinite number of fluids, in which this ſupple element can take place: but the greateſt wonder is, that earth is capable of being ſubtilized to ſuch an exquiſite degree, as by uniting and communicating with ſpirit, to perform all animal functions given it in charge by the ſoul. This is the higheſt and utmoſt refinement, which in this ſtate of being, earth is capable of; but that it may be ſtill farther refined, in order to be qualified for a future, incorruptible, and more glorious ſtate, is one of the greateſt truths which we owe to revelation.

10. To the ſecond claſs of foſſils belong thoſe which are reduced by fire to a calx. Such are, 1. Salts, all foſſils which (whether they have a ſalt taſte or not) are ſoluble in water. Common ſalt is heavier than water, and if quite pure, melts when left in the open air. If the water it is diſſolved in be boiled and evaporated, it remains in the bottom of the veſſel. It is well known to preſerve fleſh from putrefaction, and to be with great difficulty diſſolved by fire. Probably it is compoſed of pointed particles, which fix in the pores of fleſh, and by reaſon of their figure are eaſily divided by water, though not by fire. It ever comes purer out of the fire. Yet it will fuſe in a very intenſe heat.

All ſalt diſſolves by moiſture: but moiſture only diſſolves a certain quantity. Yet when it is impregnated with any ſalt, as much as it can bear, it will ſtill diſſolve a conſiderable quantity of another kind of ſalt. It ſeems, the particles of this, being of different figures, inſinuate into the remaining vacuities. Thus when a cup of water will diſſolve no more common ſalt, alum will diſſolve in it. And when it will diſſolve no more alum, ſalt-petre will diſſolve, and after that, ſal ammoniac.

The moſt remarkable ſalt-mines in the world, are in the village Williſca, five leagues from Cracow in Poland. They were firſt diſcovered above 500 years ago, in the year 1251. Their depth and capacity are ſurpriſing.

priſing. They contain a kind of ſubterranean republic, which has its laws, polity, carriages, and public roads for the horſes which are kept there, to draw the ſalt to the mouth of the quarry. Theſe horſes after once they are down, never ſee the light of the day again. But the men take frequent occaſions of breathing the upper air. When a ſtranger comes to the bottom of this abyſs, where ſo many people are interred alive, and where ſo many were born, and have never ſtirred out, he is ſurpriſed with a long ſeries of lofty vaults, ſuſtained by huge pillars, which being all rock ſalt, appear by the light of flambeaus that are continually burning as ſo many cryſtals, or precious ſtones of various colours.

11. To this claſs, ſecondly, belong ſtones, which are hard, rigid, void of taſte, reducible to duſt by the hammer, and into a calx by fire. It is probable, that ſtones, like ſalts and moſt foſſils, are generated from a fluid, which gradually hardens into ſtone, by the evaporation of its finer parts.

Mr. Tournefort obſerved, that in the famous labyrinth of Crete, ſeveral perſons had engraved their names in the living rock, of which its walls are formed: and that the letters ſo engraven, inſtead of being hollow, as they were at firſt, ſtood out from the ſurface of the rock. This can no otherwiſe be accounted for, than by ſuppoſing the cavities of the letters filled inſenſibly, with matter iſſuing from the ſubſtance of the rock, even in more abundance than was needful to fill thoſe cavities. Thus is the wound of a knife healed up, much as the fracture of a bone is conſolidated, by a callus formed of the extravaſated nutritious juice, which riſes above the ſurface of the bone. Such callus's have been obſerved to be formed on other ſtones, which were reunited after they had been accidentally broken. Hence it is manifeſt, that ſtones grow in the quarry, and conſequently are fed; and that the ſame juice, which nouriſhes them, ſerves to rejoin their parts when broken. There is then no room to doubt, that they are organized, and draw their nutritious juice from the earth, which is firſt filtrated and prepared in the

the ſurface of the ſtone, and thence conveyed to all the other parts.

Doubtleſs the juice which filled the cavities of thoſe letters was brought thither from the root of the rock, which grew as corals do, or ſea-muſhrooms, which every one allows to grow: and yet they are true ſtones.

Indeed there are ſome ſpecies of ſtones, whoſe generation can no otherwiſe be accounted for, than by ſuppoſing them to come from a kind of ſeeds, which contain their organized parts in miniature. But many ſorts of ſtones were once fluid; witneſs the various foreign bodies found therein.

That even pebble ſtones grow, may be proved to a demonſtration, by an eaſy experiment. Weigh a quantity of pebbles and bury them in the earth. After a time dig them up, and on weighing them again, you will find they have gained a very conſiderable addition.

The vegetable mould or ſurface of the earth, is made up of ſands, clays, marls, loams, rotten ſtalks and leaves of herbs, ſerving both as a proper bed and covering, and as a receptacle and conductor of moiſture to the roots of trees and plants. Sands and pebbles may be conſidered as drains, for carrying off the redundant moiſture, to places where it may be ready to ſupply the place of what is continually riſing in exhalations. But leſt the ſtrata of ſand ſhould be too thick, ſmall ones of clay are often placed between, to prevent the moiſture from departing too far from where it may be of uſe. And leſt theſe thin partitions of clay ſhould let the particles of ſand inſinuate into them, and thereby let the moiſture paſs through, thin cruſts of a ferrugineous ſubſtance are placed above and beneath each of theſe clayey ſtrata: by which means the clay and ſand are effectually kept aſunder.

Suppoſing ſome ſtones are organized vegetables, and are produced from ſeed, yet moſt ſorts of ſtones ſeem to be unorganized vegetables. Other vegetables grow by a ſolution of ſalts, attracted into their veſſels. Moſt ſtones grow by an accretion of ſalts, which often

ſhoot

ſhoot into regular figures. This appears by the formation of cryſtals upon the Alps. And that ſtones are formed by the ſimple accretion of ſalts, appears from the tartar on the inſide of a claret veſſel; and ſtill more clearly, from the formation of a ſtone in the human body. The air is in many places impregnated with ſuch ſalts or ſtony particles: and theſe aſcending from the cavities of the earth, may petrify wood. In this caſe the petrifying quality is not originally, either in the earth or the water: but in the riſing ſteams impregnated with ſaline or ſtony particles.

12. Many waters are generally ſuppoſed to turn other bodies into ſtone. This is aſcribed to the Lake Loghmond, in Scotland, and Lough Neagh, in Ireland. But it is a miſtake. There is not in reality any ſuch tranſmutation in thoſe bodies. Only the ſtony particles floating in the water, lodge in the pores, or on the ſurface of them. Petrifactions therefore are nothing more than incruſtations of ſtony particles, which ſurround and partly inſinuate into the bodies immerſed.

With regard to Lough Neagh, ſome think the petrifying quality, to be not only in the water, but in the adjacent ſoil. Many pieces of petrified wood are thrown up daily, in breaking up new ground, which that water never touched. They are often found two miles from the Lough, in great numbers, and deep in the ground, altogether like the Lough-Neagh ſtones. That theſe were once wood is certain. They burn clear, and may be cut with a knife, though not ſo eaſily as other wood.

Petrifying ſprings are impregnated, ſome with particles of ſtones, others with ferrugineous and vitriolic particles. When the ſtony ones drop on wood, or other vegetables, they coagulate upon it, and by degrees cover it with a ſtony coat. If this be broke before the wood is rotted away, you find it in the heart of the ſtone. If the wood is rotted, you will find a cavity in the ſtone; but this alſo in time will be filled up with ſtony particles. Sometimes indeed theſe waters pene-

trate

trate the pores of the wood, fill them up with their ſtony particles, and by their burning quality proceeding from lime-ſtone, deſtroy the wood, and aſſume the ſhape of the plant.

Metallic particles moſtly act, by inſinuating into the pores of wood or other vegetables, without increaſing their bulk, or altering their texture, though they greatly increaſe their weight. Such is the petrified wood in and near Lough-Neagh. It does not ſhew any outward addition of matter, and preſerves the grain of wood. All the alteration is in the weight and cloſeneſs, by the mineral particles pervading and filling the pores.

That there are mines near the lough, we may gather from the great quantity of Iron ſtones found on its ſhores, and from the yellowiſh ochre and clay in many places near it. Now whatever ſprings run through theſe, will be impregnated with metallic particles. And if they riſe in the middle of a river or lake, and in their courſe meet with wood or other vegetables, theſe particles will inſinuate and lodge themſelves in their pores, and by degrees turn them into ſtone.

That ſuch ſprings are under this lake, appears from hence, that in the great froſt, 1740, though the lake froze over, ſo as to bear men on horſeback, yet ſeveral circular ſpots remained unfrozen. Hence it appears, that this petrific quality is not in all parts of the lake, but here and there only. As to the trees which are found petrified and buried at a ſmall diſtance from the lake, probably it was broader once than it is now, ſo that what was then under water, is now dry land. If ſo, theſe trees might have been petrified, in the part which was then overflowed, though it is now dry.

13. It is certain, that water impregnated with metallic particles, when falling on wood or other vegetables, will coagulate upon it, as was obſerved above, and cover it with a metallic coat. It is alſo certain, that the vegetables included therein, are gradually deſtroyed, till the ſame matter which firſt formed the cruſt, takes up the whole ſpace which they occupied before. But it is not only wood and other vegetables, which

which are capable of being thus acted upon, firſt cruſted over and then deſtroyed. A ſhovel of iron ſome years ſince lying in the water, in the county of Wicklow, in Ireland, was obſerved to be incruſted with copper, which gave occaſion to an important diſcovery. A gentleman who viſited the place on purpoſe to examine the truth of what was commonly reported, obſerves, "I ſaw the iron bars impregnated with copper. I was an eye witneſs to the change in all its progreſs: and ſo were thouſands beſides. I ſaw the maſons laying a chain of new ſtone troughs, for the copper water to run through. I ſaw the men alſo laying the iron bars, on wooden rafters, in theſe troughs. I ſaw the iron bars lifted up out of ſome troughs, where they had lain from one to eight months: and ſaw them incruſted over with copper, and corroded more or leſs, (ſome of them to very thin plates) according to the time they had lain in the water. I ſaw ſome of the troughs emptied, wherein the bars were wholly diſſolved; and the labourers were throwing up with ſhovels the copper, which lay on the ſtones in the bottom of them. It was like mud, as it lay wet in the heap, but became duſt as it dried. I alſo ſaw ſeveral pieces of copper, which had been made out of their copper mud.

"This water is ſuppoſed to flow over a vein of copper in the neighbouring mountain. It is of a ſharp, acid taſte, and of a blue colour. It is received and collected in thoſe troughs, wherein the iron bars are placed: which after lying in the water, often not above three months, are entirely conſumed: then at the bottom of the troughs, a quantity of copper is found, in the form of coarſe ſand. And it is remarkable, that there is a greater quantity of this copper, than there was of iron.

"But by what principle is this effect produced? In order to diſcover this I made the following experiments:

"1. Some ſmall iron nails put into the water, were in four minutes covered with a ſubſtance of a copper colour. And during that time the nails gained four grains in weight. The water had the very ſame effect on ſilver and tin, but not on gold. Hence we obſerve, the colour and increaſe of weight were owing to the

adhesion of the particles of the matter dissolved in the water by an acid, which could not penetrate gold.

" 2. In order to determine the quantity and quality of this matter, I put two drachms of small iron nails into three ounces of the water. After they had lain therein four and twenty hours, I found the surface of the water covered with a thick scum, exactly like that which usually covers a chalybeate spaw. I observed, likewise, it had lost the blue colour, and sharp, vitriolic taste. It was quite transparent, and at the bottom lay a brown powder, which when dried, weighed fourteen grains. This powder, melted without any flux, produced twelve grains of pure copper. The nails also (which had lost eight grains) were in several places covered with a solid lamina of pure copper. The water being afterward filtrated and evaporated, afforded a pure green vitriol.

" 3. From the spring water treated in the same manner, I obtained a blue vitriol, the basis of which is copper. From all these experiments it appears, that a mineral acid is the active principle in this water, which being diffused through the copper ore, unites itself with that metal, and forms a vitriol. This is dissolved by the water, and remains suspended therein, till it meets with the iron in the trough, and by which it is more strongly attracted than by the copper. Therefore it quits the copper, corrodes the iron, and changes it into a vitriol, which is again dissolved and carried off in the stream. Mean time the copper, deserted by its acid, falls by its specific gravity to the bottom of the trough.

" It appears then upon the whole, that this admirable process of nature, whereby one metal seems to be turned into another, is no more than a simple precipitation of the copper, by means of them."

In the Lower Egypt, there is a vast sandy desert, called the desert of St. Macarius. One large plain herein is called by a name which signifies, The Sea without water. This is strewed over with limbs of trees which are entirely petrified: very probably by means of the nitre, with which this whole country abounds.

The

The change of wood into ſtone is not the only wonder here. The ſand is alſo changed into eagle-ſtones. Theſe ſtones are found two or three fingers breadth beneath the ſurface of the earth, in little mines, ſome paces long and broad, about half a mile from each other. It is thought that in theſe places, there oozes out of the earth, a ſort of metallic matter, which ferments with the burning ſand, and in fermenting aſſumes ſome kind of roundiſh figure, and attaches to itſelf more and coarſer ſand. Afterward it hardens by degrees, and grows black through the heat of the ſun.

The eagle-ſtone when in the mine is ſoft and brittle as an egg, and of a bright yellow or violet colour, but after being expoſed to the air, it turns brown or black, and hardens gradually. Likewiſe after a few days, moſt of theſe ſtones, will, if ſtruck, ſound like little bells.

Not far off is a vaſt heap of ſand, which they call the Eagle-ſtone Hill, becauſe it is covered over with great rocks of the very ſame matter whereof the ſmall eagle-ſtones are formed.

But what ſhall we judge of thoſe petrified ſhells, which have been dug up in many places? Some indeed are not petrified. Near Reading, in Berkſhire, for ſucceeding generations, a continued body of oyſter-ſhells have been found through the circumference of five or ſix acres of ground. Beneath is a hard, rocky chalk, on which the ſhells lie in a bed of green ſand, about two feet thick. Above are various ſtrata for at leaſt eighteen feet. The ſhells are ſo brittle, that in digging, one of the valves will frequently drop from its fellow. But ſeveral are dug out entire; nay, ſome double oyſters, with all their valves united.

In a quarry at the eaſt end of Broughton, in Lincolnſhire, there is a clay under the ſtone, in which are numberleſs fragments of the ſhells of ſhell-fiſh of various kinds. And there are ſometimes found whole ſhell-fiſh, with their ſhells on, in their natural colours, only bruiſed and broken, and ſome ſqueezed flat by the weight of earth, which was caſt upon them at the deluge.

There is another quarry, ſouth of the town, of blue, hard ſtone, (probably a pure clay in ſome antediluvian lake) in which are numberleſs ſhell-fiſh of various ſorts, but ſo united to the ſtone, that it is hard to get them out whole. They are all in the ſurface of the quarry, within a foot of the top. On the ſurface there are many ſhell-fiſh half in the ſtone, half out. That part which is within the quarry is whole, but is a hard ſtone. That which is without, is all conſumed, but a little of the edges, which are plain ſhell.

Some of the ſhell-fiſh in this quarry are half open, and filled with the matter of the bed on which they lie. Some of them are broken, others bruiſed: the edge of one fiſh is ſometimes thruſt into the ſides of another. One ſhell of ſome is thruſt half way over the other, and ſo they are petrified together.

Among theſe there are ſeveral great horſe-muſcles, ſuch as breed in rivers and ponds. And in the fields and ſtones near Bramby and Frodingham is found a ſort of fiſh bending like a ram's horn, and creaſed like one on the outſide. The bed wherein, it ſeems, this fiſh bred, is about a foot thick: in which are millions of the fiſh, ſticking half within the ſtone, half without. And this ſhell being extremely durable, even the part ſticking out, is not conſumed, as it uſually is in others, but remains whole and entire.

14. From ſtone burnt to duſt ariſes lime, which has this remarkable property, that if cold water be poured upon it, it preſently heats and boils up. In order to account for this, ſome have ſuppoſed, that ſome ſubtle matter is lodged in the pores of the lime, (perhaps many of thoſe particles of fire, whereby the ſtone was reduced to duſt) which when the water inſinuates into thoſe pores, occaſions the ſame kind of ebullition, as if it was poured on any other burning ſubſtance.

15. Moſt precious ſtones are tranſparent, and ſtrike the eye with vivid and various colour. Probably they were once fluid bodies, which while in that ſtate were mixed with metallic or mineral juices. Their tranſparency likewiſe makes this probable, and ſo does their outward

outward configuration. For many bodies hardening into ſolids ſhoot into cryſtals, juſt as is obſerved of ſeveral kinds of precious ſtones: and to this their inward ſtructure anſwers. For in many we may obſerve the thin plates or coats one over the other, juſt as we ſee in thoſe mineral ſubſtances, which were once fluid. Their colours might be owing to ſome mineral juice or exhalation, which tinctured them before their pores were fully cloſed. This is the more probable, becauſe many gems loſe their colour if they lie long in the fire: and becauſe generally coloured gems are found over metallic or mineral veins.

Dr. Boerhaave takes cryſtal to be the baſis of all precious ſtones, which aſſume this, or that colour, from the metallic or mineral ſteams mixed with the primitive cryſtalline matter. But how is cryſtal itſelf formed? An Italian writer gives a particular account of this. In the Val-Sabbia, ſays he, I obſerved ſome parts of a meadow bare of all herbs. Here, and no where elſe thereabouts, the cryſtals are generated. And whenever there is a ſerene and dewy ſky, if all the cryſtals that can be found over night, are taken away, others will be found in the ſame place in the morning. Having obſerved, there is no ſign of any mineral ſteam near, I conclude they are produced by ſteams of nitre. Theſe may at the ſame time hinder vegetation in thoſe places, and coagulate the dew that falls thereon. As nitre is the natural coagulum of water, ſo it ever retains its ſex-angular figure. The largeſt cryſtals known were found in the mountains of Grimiule, between vaſt ſtrata of ſtones. The biggeſt of them was near three feet in length, and little leſs in circumference. It weighed two hundred and fifty pounds: others weighed leſs and leſs, to thoſe of ten pounds, which were the ſmalleſt there. They were of the ſame figure; ſexangular columns, terminated by ſexangular pyramids at one end, and at the other fixed to the rock. They were in general perfectly clear throughout, but in ſome the baſe was foul, in others the point.

If a ſolution of alum is permitted to cryſtalize quietly, it ſhoots into planes, of eight, ſix, four and three ſides. But beſide this, particles when excited to action

by

by a certain degree of heat, arrange themſelves into regular and delightful ſtar-like figures of different ſizes. Many of theſe have long ſtreaming tails, and reſemble comets. Others ſhoot into an infinite number of parallel lines, beautiful beyond deſcription. Theſe configurations are no leſs conſtant in their forms than the cryſtals on which they grow. And they are equally tranſparent, but the figures produced are ſo extremely different, that every conſiderate obſerver muſt judge them to be owing to ſome very different property in nature. But what property? Who can determine? Indeed how little do we know of the moſt common things? The very elements that ſurround us, the fire, the water, the air we breathe, the earth we tread upon, have many properties beyond our ſenſes to reach, or our underſtanding to comprehend.

Dr. Borlaſe ranges cryſtal itſelf and all gems under the head of ſpar, which, ſays he, are only finer and purer ſubſtances of the ſpar kind.

All ſpar has been in a ſtate of fluidity. In ſome are found ſtraws and other light bodies. Yet time adds nothing to their firmneſs: but they are as hard when firſt conſolidated, as ever they will be. But why do we find no ſpars in their fluid ſtate? Becauſe while the matter of them remains incorporated with the water, it is not to be diſtinguiſhed from it, and as ſoon as it is deſerted by the water, wherein it ſwims, it commences ſtone. It is by water that the ſparry atoms are waſhed out of their repoſitories, and collected into a tranſparent or opake juice. As ſoon as the redundant water is drained off or evaporated, the ſtony parts accede to a cloſer union. They are aſſiſted therein, either by cold, compreſſing the parts, or by ſudden evaporating heat. Thus the ſtone is formed, ſo much water reſting in the pores, as is neceſſary to fix it into a conſiſtency. Hence may ariſe ſome queries.

1. Whether ſpar is not the univerſal gluten of ſtones diſtinguiſhed from each other by various mixtures of earthy, mineral, or metallic particles, but all united by the ſparry liquor? Perhaps there is ſcarce any ſand, ſtone, or ore, which either by the naked eye or glaſſes, may not be diſcerned to have a portion of ſpar, clearer or opake, in its compoſition.

2. Whether

2. Whether theſe and all other ſorts of ſtones are not continually forming in the earth?

3. Whether there are not quarries of ſtone, which when left unwrought for a conſiderable time, yield a freſh ſupply of ſtone, in thoſe channels which had been before thoroughly cleared?

A very peculiar kind of precious ſtone is what is termed a turquois. It is of the opake kind, and commonly of a beautiful blue colour. And yet it has lately been made very probable, that theſe ſhining ſtones are originally no other than the bones of animals. In the French mines they are frequently found in the figure of teeth, bones of the legs, &c. And turquoiſes half formed are compoſed of laminæ, like thoſe of bones, between which petrifying juice inſinuating, binds them cloſe together. And the more imperfect the ſtones are, the more diſtinguiſhable are the different directions of the fibres and their laminæ, and the nearer reſemblance they bear to fractured bones.

The blue turquois, is indeed no other than foſſil bone, or ivory ſaturated with copper diſſolved in an alkaline menſtruum; the green turquois is the ſame ſubſtance, intimately penetrated by a cupreous matter diſſolved in an acid menſtruum.

16. The loadſtone is found in iron mines, and reſembles iron both in weight and colour. Its moſt remarkable properties are, turning to the poles, and attracting iron. As to the former, when it moves without hindrance, it conſtantly turns one end to the north, the other to the ſouth: only declining a little to the eaſt or weſt. If two loadſtones are brought within a certain diſtance of each other, that part of one which is toward the north pole of the earth, recedes from that part of the other which reſpects the ſame pole. But it accedes to it, if the ſouthern pole of the one be turned toward the ſouth pole of the other. The needle touched with the loadſtone, when on this ſide the equinoctial line, has its north point bending downward, on the other ſide, its ſouth point: under the line, it turns any way, and is of no uſe.

As

As to its attractive power, it not only ſuſtains another loadſtone, (provided the north pole of the one be oppoſed to the ſouth pole of the other) but iron alſo. Likewiſe if ſteel-dust be laid upon a loadſtone, it will ſo diſpoſe itſelf, as to direct its particles ſtrait to the poles, whence they will be moved round by little and little, till they are parallel to the axis of the loadſtone. It communicates its virtue to iron, and if it be armed with (that is, fixed in) iron, its force is greatly increaſed. It loſes its force either by fire, or by letting two loadſtones lie together, with the north pole of one oppoſed to the north, or the ſouth pole of one to the ſouth of the other. Theſe plain phænomena of the loadſtone we know: the cauſe of them we know not.

From late obſervations it appears, that the loadſtone is a true iron ore, and is ſometimes found in very large pieces, half loadſtone, half common ore. In every one, 1. There are two poles, one pointing north, the other ſouth. And if it be divided into ever ſo many pieces, the two poles will be found in each piece. 2. If two loadſtones be ſpherical, one will conform itſelf to the other, as either would do to the earth, and will then approach each other: whereas in the contrary poſition, they recede from each other. 3. Iron receives virtue, either by touching, or by being brought near the ſtone: and that variouſly, according to the various parts of it which it touches. 4. The longer the iron touches the ſtone, the longer it retains the virtue. 5. Steel receives this virtue better than iron. 6. In theſe parts the ſouth pole of a loadſtone lifts more iron than the north pole. 7. A plate of iron interpoſed hinders the operation of the loadſtone; but no other body, no not glaſs itſelf. 8. A touched wire, if bent round in a ring, quite loſes its virtue. But though bending thus deſtroys its virtue by day, it will not deſtroy it in the evening. Where is the philoſopher in the world, who can account for this? 9. Loadſtones without any known cauſe, act ſometimes at a greater diſtance than other times. That of the Royal Society will keep a key ſuſpended to another, ſometimes at the height of ten feet, ſometimes not above four. As ſtrange it is, the variation of the needle is different at different times of the day. 10. If a touched wire be ſplit, the

poles

poles are ſometimes changed (as in a ſplit loadſtone.) And yet ſometimes one half retains the ſame poles, and the other half has them changed. 11. Touch a wire from end to end with the ſame pole of the loadſtone, and the end firſt touched turns contrary to the pole that touched it. But touch it again from end to end with the other pole of the ſtone, and it will turn juſt the contrary way. 12. Touch a wire in the middle with one pole of the ſtone, and the pole of the wire will be in that place: the two ends will be the other pole. 13. The poles of a ſmall loadſtone may preſently be changed, by applying them to the oppoſite poles of a large one. 14. Iron bars which ſtand long in an erect poſition, grow permanently magnetical; the lower end of them being the north pole, and the upper the ſouth pole. 15. The ſame effect follows, if you only hold them perpendicularly: but if you invert them, the poles will ſhift their places. 16. Fire, which deprives a loadſtone of its attractive virtue, ſoon gives verticity to a bar of iron, if it be heated red hot, and then cooled in an erect poſture, or directly north and ſouth. 17. A piece of Engliſh oker, thus heated and cooled, acquires the ſame verticity. 18. The verticity thus acquired by a bar of iron, is deſtroyed by two or three ſmart blows on the middle of it. 19. Either a piece of iron or a loadſtone being laid on a cork that ſwims freely in the water, whichever of the two is held in the hand, the other will be drawn to it. This proves that the iron attracts the ſtone, juſt as much as it is attracted by it. 20. Draw a knife leiſurely from the handle to the point over one of the poles of a loadſtone, and it acquires a ſtrong magnetic virtue. But this is immediately loſt, if you draw it over the ſame pole from the point to the handle. Laſtly, a loadſtone acts with as great force in vacuo, as in the open air.

The chief laws of magnetiſm are theſe, 1. The loadſtone has both an attractive and a directive power: iron touched by it has only the former. 2. Iron ſeems to conſiſt almoſt wholly of attractive particles; loadſtones of attractive and directive together, probably mixed with heterogeneous matter, as not having been purged by fire like iron. And hence iron, when touched, will lift up a much greater weight than the

loadſtone that touched it. 3. The attractive power of armed loadſtones, is cæteris paribus, as their ſurfaces. 4. Both poles of the loadſtone equally attract the needle till it is touched. Then it is that one pole begins to attract one [illegible] and repel the other. But even the repelling pole will attract upon contact, or at a very ſmall diſtance. But how odd are the following experiments. I cut a piece, ſays Dr. Knight, of a laadſtone, into an oblong ſquare. In this I placed the magnetic virtue in ſuch a manner, that the two oppoſite ends were both ſouth poles, and the middle quite round was a north pole. I made the two oppoſite ends of another ſtone, north poles, the oppoſite ſide ſouth poles. An irregular ſtone had two broad, flat ſurfaces oppoſite to each other. I made half of each of theſe ſurfaces a north pole, and the other half a ſouth pole. So that the north pole of one ſurface was oppoſite to the ſouth pole of the other. I took a ſtone that had a grain very apparent, running the lengthways of it. At one end of it I placed a north pole, ſurrounded by a ſouth: at the other a ſouth ſurrounded by a north pole: ſo that the edges of each ſurface had a different pole from that which occupied the middle.

Many varieties of this kind might eaſily be deviſed. But theſe examples are ſufficient to ſhew, how manageable the magnetic virtue is, with reſpect to its direction; and how defective all the hypotheſes are, which are brought to account for the phænomena of the loadſtone.

Mr. Howard ſailed to Barbadoes in company with another ſhip, commanded by one Groſton. Suddenly a terrible clap of thunder broke Groſton's fore-maſt, and did ſome damage to his rigging. When the noiſe was paſt, he was ſurpriſed to ſee Mr. Groſton's ſhip ſteering directly homeward. He tacked and ſtood after him, and found that Mr. Groſton did indeed ſteer by the right point of his compaſs, but that the card was turned round, the north and ſouth point having changed places. If he ſet it right with his finger, as ſoon as it was ſet at liberty, it returned to its former poſture. And on examination, he found every compaſs in the ſhip had undergone the ſame change.

An

An odd diſcovery has been lately made, that not only iron, as has been generally thought, but braſs too, by being hammered and properly touched, will contract a true magnetic virtue. And perhaps it will be hereafter diſcovered, that other metals may receive the ſame.

Before cloſing this article, it may be proper to obſerve, firſt, the peculiar qualities wherewith ſome other ſtones are endued; and ſecondly, the remarkable uſes they are of to us. As to the former, we may obſerve, 1. The colour. The carbuncle and ruby ſhine with red, the ſapphire with blue, the emerald with green, the topaz with a yellow or gold colour; the amethyſt is as it were tinctured with wine, the opal varies its colour like changeable taffeta, as it is variouſly expoſed to the light. Obſerve, 2. The hardneſs wherein ſome ſtones exceed all other bodies, the diamond in particular, which is ſo extremely hard, that no art is able to counterfeit it. 3. As to the uſes, ſome are ſerviceable for building, and for many ſorts of veſſels and utenſils; for pillars and ſtatues; for porticos, conduits, palaces, as freeſtone and marble: ſome to burn into lime, ſome (with the mixture of kelp) to make glaſs, as common flints; ſome to cover houſes, as ſlate; ſome for marking, as chalk, which ſerves alſo to manure land, and for medicinal uſes; ſome to make veſſels which will endure the fire. I might add the warming-ſtone, digged in Cornwall: which being once well heated at the fire, retains its heat for a conſiderable time.

17. Of the third claſs are inflammable foſſils, the chief of which are ſulphur and bitumen. Both are highly inflammable: but the ſubſtance of bitumen is more fat and tenacious; whereas ſulphur may eaſily be broken, and reduced to a fine powder.

The bitumen of the Latins was by the Greeks called aſphaltos. It is a black, ſolid, brittle ſubſtance, reſembling pitch. It is chiefly found ſwimming on the Dead Sea, where anciently ſtood Sodom and Gomorrah. It is caſt up from time to time from the bottom to the ſurface, where it gradually condenſes by the heat of the ſun. It burns as violently as naphtha; but is of a firmer conſiſtence.

Aſphaltos

Aſphaltos is alſo a kind of bituminous ſtone, found near the ancient Babylon, and lately in the province of Neufchatel, which properly mixed makes an excellent cement, incorruptible either by air or water. With this it is ſuppoſed the walls of Babylon were built.

Jet ſeems to be formed in the earth of a bituminous juice. It is a light, ſmooth, pitchy ſtone. It is fiſſile, and works like amber: the beſt in the world is ſaid to be found in Yorkſhire. It readily catches fire, flaſhes and yields a bituminous ſmell. Nearly reſembling this is the channel coal, found in ſeveral parts of Lancaſhire, which burns with an even, ſteady flame, like a candle or torch.

18. Amber is a kind of foſſil pitch, the veins of which run chiefly at the bottom of the ſea. It is hardened in tract of time, and caſt on ſhore by the motion of the ſea. It was long thought that none could be found but in Pruſſia: but it has ſince been found in Sweden, on the ſhores of the iſle of Beorkoo, though ſituate in a lake whoſe water is ſweet. Nay, it is digged out of the earth, at a conſiderable diſtance from the ſea, and not only in ſandy, but in firm ground.

19. But the moſt extraordinary of all foſſils is the aſbeſtos. It ſeems to be a ſpecies of alabaſter, and may be drawn into fine ſilky threads, of a greyiſh or ſilver colour. It is indiſſoluble in water, and remains unconſumed even in the flame of a furnace. A large burning-glaſs indeed will reduce it to glaſs globules; but common fire only whitens it. Its threads are from one to ten inches long, which may be wrought into a kind of cloth. This the ancients eſteemed as precious as pearls. They uſed it chiefly in making ſhrouds for emperors or kings, to preſerve their aſhes diſtinct from that of the funeral pile. And the princes of Tartary at this day apply it to the ſame uſe. The wicks for their perpetual lamps were likewiſe made of it. A handkerchief of this was long ſince preſented to the Royal Society. It was twice thrown into a ſtrong fire, before ſeveral gentlemen. But in the two experiments it loſt not above two drachms of its weight.

And

And what was very remarkable, when it was red-hot, it did not burn a piece of white paper, on which it was laid.

But there is a kind of aſbeſtos wholly different from that known to the ancients. It is found, ſo far as we yet know, only in the county of Aberdeen, in Scotland. In the neighbourhood of Achintore, on the ſide of a hill, in a ſomewhat boggy ſoil, about the edges of a ſmall brook, there is a ſpace of ten or twelve yards ſquare, in which pieces of foſſile wood petrified lie very thick. Near this place, if the ground be dug into with a knife, there is found a ſort of fibrous matter, lying a little below the ſurface of the ground, among the roots of the graſs. This the knife will not cut: and on examination it proves to be a true aſbeſtos. It lies in looſe threads, very ſoft and flexible, and is not injured by the fire.

Yet it is ſometimes collected into parcels, and ſeems to form a compact body. When this however is more nearly examined, it appears not to be a real lump, but a congeries reſembling a pledget of preſſed lint, and being put into the water, it ſeparates into its natural looſe threads.

A ſtranger diſcovery has ſtill been lately made. The proprietor of a forge, upon taking down his furnaces, to repair them, found at the bottom a great quantity of a ſubſtance, which upon repeated trial, effectually anſwered all the uſes of the aſbeſtos. It was equally well manufactured either into linen or paper, and eq̄ually well endured the fire. Upon proſecuting the inquiry, it appeared to him, that both the native aſbeſtos (at leaſt one ſpecies of it) and this obtained from the forge, were nothing more, than what he terms calcined iron, deprived, whether by nature or by art, of its inflammable part: and that by uniting the inflammable part, either with this, or the foſſile aſbeſtos, it may at any time be reſtored to its primitive ſtate of iron.

But it is certain there is aſbeſtos which has no relation to iron. Both in Norway and Siberia, there are petrifying waters, which, pervading the pores of wood lying therein, fill it with ſtony particles; and when by a cauſtic, corroſive power, derived from lime

lime, they have deſtroyed the wood, a proper aſbeſtos remains, in the form of a vegetable, which is now no more. To which of theſe does the following belong?

Signor Mareo Antonia Caſtagna, ſuperintendant of ſome mines in Italy, has found in one of them a great quantity of linum aſbeſtum. He can prepare it ſo as to make it like either a very white ſkin, or a very white paper. Both of theſe reſiſt the moſt violent fire. The ſkin was covered with kindled coals for ſome time: being taken out, it was ſoon as white as before: neither had it loſt any thing of its weight. The paper alſo was tried in the fire, and without any detriment. Neither could any change be perceived, either with regard to its whiteneſs, fineneſs, or ſoftneſs.

PART THE FOURTH.

Of Earth, Water, Fire, Air, and Meteors.

CHAP. I.

Of Earth and Water.

1. *Of the formation of the Earth.*
2. *Sand probably its general Cover.*
3. *An inundation of Sand.*
4. *Of Mountains.*
5. *The Benefit of Mountains.*
6. *The Height of Mountains.*
7. *Of Water.*

8. *Of*

8. *Of Ice.*
9. *Of Fountains.*
10. *Of the Sea.*
11. *Of Rivers and Iſlands.*
12. *Of the Baſon of the Sea.*
13. *Of the Tides.*
14. *Of Currents in the Sea.*
15. *Of ſubterraneous Trees.*
16. *Origin of Bogs.*

1. THE earth or terraqueous globe is a congeries of many different bodies. It contains ſand, clay, various ſorts of earth, ſtones, ſalts of various kinds, ſulphur, bitumen, metals, minerals, and other foſſils almoſt innumerable. Upon the earth are the waters, and on or near its ſurface, animals and vegetables of all kinds. But how was this whole maſs formed into mountains, vallies, ſeas, rivers, and iſlands? Des Cartes advances one hypotheſis. Dr. Burnet another. Mr. Hutchinſon a third. And each world-builder advances plauſible reaſons for his own hypotheſis. But none of thoſe reaſons are demonſtrative: higher than a probability they cannot go.

That the earth is round, manifeſtly appears from the eclipſes of the moon, in all which the ſhadow appears circular, which way ſo ever it be projected. The natural cauſe of its roundneſs, is the great principal of attraction, which the Creator has ſtamped on all the matter of the univerſe, whereby all bodies, and all the parts of bodies continually attract each other. By this means, as all the parts of bodies tend naturally to their centre, ſo they take a globous figure, unleſs ſome other more prevalent cauſe interpoſe. Hence drops of quickſilver put on a ſpherical form, the parts ſtrongly attracting each other. Drops of water have the ſame form, when falling in the air, but are only half round, when they lie on a hard body, becauſe their gravity overpowers their attraction. Yet the earth is not exactly round, but ſwells out towards the equator, and is flatter, towards the poles, which is ſuppoſed to be occaſioned by the diurnal rotation of the earth on its axis. By this means the greater diameter exceeds the leſs, about 34 miles. What the earth loſes of its ſphe-

ricity

ricity by mountains and vales is nothing conſiderable: the higheſt eminence being ſcarce equivalent to the ſmalleſt protuberance on the ſurface of an orange. The diameter of the earth is ſuppoſed to be 7967 miles.

In the terraqueous globe are, 1. The external part, from which vegetables grow, and animals are nouriſhed: 2. The middle part, which is poſſeſſed by foſſils, and extends farther than human labour can penetrate: 3. The internal, which ſome ſuppoſe to be a great loadſtone: ſome a large maſs of fire: ſome a collection of waters: and others, a hollow ſpace inhabited by animals, which have their ſun, moon and all other conveniences, peculiar to themſelves. But indeed of that we know nothing. The deepeſt cavities natural or artificial, known to us, ſcarce penetrating a mile below the ſurface.

In the external part we meet with various ſtrata which were doubtleſs formed by the general deluge. The exterior parts of the earth were then diſſolved, and mixed with the waters in one common maſs. Afterward they ſunk, nearly according to the laws of gravity, the heavieſt firſt, and the lighter in their order. So were theſe ſtrata formed, which hardening by degrees, have continued ever ſince. It is probable, theſe lay more regularly at firſt, but have been much changed in proceſs of time, and their order diſturbed by earthquakes, volcanos and divers other cauſes.

The earth is nearer the ſun at Chriſtmas than at Midſummer, as appears both from the ſun's apparent diameter, being greater in December than in June, and from its motion, being then ſwifter. Hence it is that there are about eight days more in the ſummer half year from March to September, than in the winter half year from September to March.

That the earth moves round its own axis, not the ſun and ſtars round the earth, may appear from this ſingle conſideration. All the planets revolve in more or leſs time, as their orbits are greater or leſs. If then they moved round the earth, they muſt revolve in unequal times, according to their orbits; not all in the ſame time, in four and twenty hours, as they ſeem to do. Therefore they do not move round the earth; but the earth, as the reſt, round its own axis.

That

That it moves alſo round the ſun, appears thus. All bodies which turn round each other, muſt gravitate towards each other; conſequently if the ſun graviates to the earth, ſo muſt the earth to the ſun. Now it is demonſtrable, that when two bodies gravitate to each other, without approaching each other in right lines, they both turn round their common centre of gravity. But the earth being no more than a point to the ſun, the common centre of theſe two bodies, will be within the body of the ſun itſelf, and not far from the centre of it. The earth therefore turns round a point which is in the ſun: conſequently round the ſun. Indeed to ſuppoſe the earth at reſt, deſtroys all the order and harmony of the univerſe, annuls its laws, and ſets every part at variance, with the others. It renders the motions of the planets utterly inexplicable, which are otherwiſe plain and ſimple.

Nor is the motion of the earth, whatever is vulgarly ſuppoſed, contrary to any part of the ſcripture. No other ideas are to be affixed to the words of ſcripture, than ſuch as occur to one who looks at the thing ſpoken of. By the ſun's riſing therefore, when mentioned in ſcripture, we are to underſtand no more than the ſun's appearing again in the horizon, after he had been hid below it: and by his ſetting, his ceaſing to appear. And when the ſun and moon are ſaid to ſtand ſtill, it means only, that they did not change their ſituation in reſpect of the earth: that the ſun ſtill appeared juſt over Gibeon, and the moon over the valley of Ajalon. If it be ſaid, "But David ſpeaks of the ſun running its courſe," we may anſwer over and above, the word here uſed does not mean the orb or body of the ſun, but always his rays or beams.

2. It is probable ſand was once the exterior cover of the whole earth. All our northern mountains are more or leſs, covered with it at this day. And the higher the mountain, the coarſer the ſand. The rivers riſing in the mountains, ſtill daily bring it down in large quantities. And that it has been ſo in all ages, ſince the firſt rains fell on the earth, ſeems highly probable, in that the mouths of rivers, and entrances of harbours are uſually barred with it. And if you pierce deep

deep into the low ground near rivers, you find this mountain-ſand in great quantities: it was the more fit to be the general cover of the earth, becauſe of its great hardneſs, and conſequently durableneſs. Mountain ſand above all other, not being made (as much ſand is) by attrition, ſteadily keeps its original figure and magnitude.

All ſands are either natural or factitious. Natural ſands are thoſe which have been in the ſame or nearly the ſame ſtate from the creation, diffuſed through all the parts of the earth. Sand viewed in a microſcope, is no more than a parcel of little ſtones: doubtleſs therefore they muſt have begun to exiſt, and been formed by the ſame laws that ſtones were formed by. Now ſtones were formed firſt into hard and ſolid maſſes, in proportion to the quantity of ſimilar materials, and proper cement. Where there was a great quantity of lapideous particles, and few heterogeneous mixtures, there ſtrata, rocks, and large ſtones were formed. But where the lapideous particles were ſcattered and diſunited by the intervention of other bodies, there ſmall rubble-ſtones, gravel, girts, and the ſmalleſt and moſt numerous of all ſtones, ſand, coaleſced into minute glebes. This probably was the proceſs in every part of the earth; ſo that ſand is one of the primæval bodies, concreted at the ſame time with ſtones, upon the higheſt mountains, as well as in the vallies; and at the bottom of the ſea, as well as upon dry land.

Beſides this natural ſand, there is alſo a factitious one, which owes its origin to the fretting of river or ſea-water. For water always in motion, preys upon the ſtones and grinds them by degrees into ſtony powder which we call ſand: hence it is that the ſand of a particular ſtone, cove or bay has generally the ſame colour, and in a microſcope, the ſame ſtructure, as the rocks, and ſtones of the adjacent cliff and the ſtrata under the ſea, upon which the waves are perpetually working, and driving into the ſea what they daſh off from thoſe ſtrata.

3. We have heard of large bodies of ſand moving together in the deſerts of Arabia. But has any thing of the kind been known in England? There has, and that

that very lately. It is not a century, ſays Mr. Wright, ſince our ſands, near Dewnham, in Suffolk, firſt broke priſon. In a warren near Lakenheath, an impetuous ſouth-weſt wind having broken the ſand of ſome ſand-hills, the ſand blew upon the adjacent grounds, which being much of the ſame nature, the thin cruſt of barren earth was ſoon rotted and diſſolved by this ſand lying upon it, and thereby fitted to bear it company in its ſtrange progreſs. At its firſt eruption the whole magazine of ſand could not cover above eight or ten acres of land. But it increaſed into a thouſand acres before the ſand had travelled four miles. Above thirty years ſince it reached the bounds of this town, where for ten or twelve years it did no conſiderable miſchief: becauſe its courſe was then down the hill, which ſheltered it from the wind that gave it motion. But the valley once paſt, it went above a mile (up-hill) in two months time. It over-run two hundred acres of good corn that ſame year. It is now got into the body of this little town, where it has buried ſeveral houſes. And the remainder have been preſerved at more expenſe than they were worth. At the other end of the town divers houſes are buried, and our paſtures and meadows deſtroyed. A branch of the river Ouſe, upon which we border, for three miles together, is more than half filled up with ſand. And had not this interpoſed to ſtop its paſſage into Norfolk, doubtleſs a conſiderable part of that county, had ere now been left a deſolate trophy of this conquering enemy.

4. One of the moſt conſiderable parts of the earth is the mountains. There is a remarkable irregularity in their figure, and (ſo far as we can judge) an entire neglect of order in their ſituation. The far greater part of them are hollow, and contain beds of ſtone, metals or minerals. And doubtleſs ſuch there were from the creation, although not ſo high, ſteep, or rugged.

For theſe vaſt maſſes are not, as ſome have ſuppoſed, mere incumbrances of the creation: rude and uſeleſs excreſcences of the globe; but anſwer many excellent purpoſes. They are contrived and ordered by the wiſe Creator, for this grand uſe in particular, to diſpenſe the moſt neceſſary proviſion of water, to all the parts

of

of the earth; without which neither animals could live, plants grow, nor perhaps foſſils receive any increaſe. For was the ſurface of the earth even and level, there could be no deſcent for the waters, but inſtead of gliding along thoſe gentle deciivities, quite down to the ſea, they would drown large tracts of land, and then ſtagnate and putrify.

Indeed without hills, as there could be no rivers, ſo neither could there be any ſprings, which we continually find in or near high grounds, very rarely on ſpacious plains. When we do find any there, it is generally at great and inconvenient depths. And even theſe are probably owing to hills, either near, or at ſome diſtance: as we may gather from the impetuous manner wherein theſe ſubterraneous waters break out, when wells are dug in the Lower Auſtria, or in ſeveral parts of Italy. And if there are ſome iſlands, which ſeem void of mountains, and nevertheleſs are well watered, in reality the whole maſs of land is no other than one mountain deſcending gently and imperceptibly down, from the midland parts to the ſea.

5. The benefit of mountains in general is not only, that vapours driven againſt them are condenſed, ſo as to be precipitated through the chinks of the rocks, but that afterwards in their bowels they are preſerved till they form rivulets, and then rivers. Vapours would fall in rain or dew though there were no mountains, but then they would fall equally, over conſiderable places of the globe at once, and ſo would be ſucked deep in the ground, or make an univerſal puddle; whereas by means of mountains they are perpetually pouring down in particular places, and treaſuring up a conſtant ſupply to the rivers. Another conſiderable uſe of them is the determination of theſe rivers: for if there could have been rivers without mountains, yet they could only have run in a ſtrait line, if they had run at all; whereas by theſe eminences, placed up and down they make innumerable turnings and windings, whereby they enrich, fatten, and water the ſoil of ſeveral different countries in one courſe, and at laſt diſembogue in ſeveral mouths into the ſea. Laſtly, moſt hills are the neſts of metals or minerals.

minerals. Theſe by the efficacy of ſubterranean heat, converting the adjacent earths into their ſubſtance, grow as truly as animals or vegetables. I juſt mention their uſe for the production, ſhelter, and nouriſhment of ſome ſorts of vegetables and animals, which could not grow or live ſo well any where elſe. But from the whole we may ſee of what advantage theſe unſightly moles (as ſome thought them) are to the accommodations, and even neceſſities of life.

6. The height of Snowden-hill, generally ſuppoſed to be the higheſt in Great Britain, is 1240 yards. But Skiddow-hill, in Cumberland, is 1760 yards high from the level of the lake beneath. And Conagra, which riſes gradually from the head of the Bay at St. Kilda, one of the weſtern iſlands of Scotland is 1800 yards high; ſo that this may juſtly be ſtiled the Teneriff of Great Britain. The height of ſeveral mountains in France is as follows:

		Feet
Bugarach in Languedoc		3888
Le Puy de domme	in Auvergne	4860
Le Courland		5088
Le Coote		5106
Le Cantal		5904
Le Mont d'or		6180
Le Mont Ventoux in Avignon		6216
The height of the Pyrenean Mountains is,		
St. Barthelemi		7110
Le Montagne des Mauſſet		7548
Le Conigoe		8640

Probably theſe mountains may vie in height with moſt in the known world. Yet above all theſe is the Stella Piz Hail, a ſteep mountain in the Griſons, which is 9585 Paris feet above the level of the ſea; a height which the wild goats themſelves ſcarce venture to aſcend.

But Mr. Martel informs us, that the higheſt point of Mont-Blanc is higher even than this: that it is 2076 toiſes above the level of the Rhone, which added to the height of this above the ſea, makes 13115 Paris feet, or above two Engliſh miles, and two thirds of a mile.

mile. If ſo, this is the higheſt mountain in Europe, and perhaps in all the world: unleſs you except Mount Athos in Macedonia; which, according to the account of Riccioli, who meaſured it exactly, is 10,000 Italian paces high, carrying its top above the winds and clouds: a clear proof of which is, that whatever is written there in aſhes or light ſand, is found there, juſt as plain as at firſt, after ſeveral months or years.

"But is not the celebrated Mount Atlas in Africa, the wonder of all ages, far higher than this?" One who ſaw it, and travelled all over it, is beſt able to anſwer this queſtion. He writes thus:

"Barbary is bounded on the ſouth by Biledulgerid, from which it is divided by Atlas, a chain of mountains, but not of that extraordinary height or bigneſs, which the ancients attributed to it. Thoſe parts of them, ſays Dr. Shaw, which I have ſeen, are rarely, if ever equal to ſome of the mountains on our own iſland, and cannot any where ſtand in competition with either the Alps or Apenines. Atlas is a number of hills, uſually 4, 5, or 600 yards high, with an eaſy aſcent, and groves of fruit and foreſt trees, riſing up one behind another. Only here and there is ſeen a rocky precipice, of a ſuperior eminence."

The rivers Indus and Ganges, before they enter the ocean, contain between them a large peninſula, divided in the middle by a ridge of high hills, which runs from eaſt to weſt, quite to Cape Comorin. On the one ſide is Malabar, on the other Coromandel. On the Malabar ſide it is ſummer from September till April; a clear ſky, and ſcarce any rain. This is winter on the Coromandel ſide, every day and night yielding abundance of rain. So that as you croſs the hills to St. Thomas, in little more than twenty leagues, you aſcend the hill with fair ſummer weather, and deſcend with a ſtormy winter. There is a like ridge of hills in Jamaica running from eaſt to weſt through the midſt of the iſland. On the ſouth-ſide of theſe there is ſummer from November to April, on the north-ſide, winter, and ſo vice verſa.

Hence it appears, that not the leſſening the gravity of the atmoſphere only, is needful to produce rain, but likewiſe either a change of winds or a ridge of hills, to

drive

drive the particles of the vapours together. And hence it is that while the wind blows from north-eaſt in Coromandel, and on the north-ſide of the mountains in Jamaica, there are continual rains, and conſtant fair weather on the ſouth-ſide of the mountains, and in Malabar. Whereas while it blows from the ſouth-weſt, there are conſtant rains on the ſouth-ſide of the Jamaica mountains and in Malabar; but conſtant fair weather on the north-ſide of thoſe mountains and in Coromandel.

This alſo may account for the ſingularity of ſeaſons in Peru, which runs ſouthward from the line above a thouſand leagues. It is divided into three parts, long and narrow: the Lanos or plains, which run along the ſea-coaſts, the Sierras, which are hills with vallies intermixed, and the Andes, which are ſteep and craggy mountains. The Lanos are, ſome ten leagues in breadth, ſome leſs, and ſome more. The Sierra is twenty leagues in breadth, and the Andes the ſame. It is remarkable, 1. That in the Lanos, the ſouth and the ſouth-weſt winds continually blow. 2. That they never have any thunder, hail, ſnow or rain, only ſometimes a ſmall dew. 3. On the Andes it rains almoſt continually. 4. In the Sierra, which lies between, it rains from September to April, and is clear from April to September. The reaſon is plain; the conſtant wind blowing over the Lanos, finds nothing to ſtop it, and drives its vapours into rain. But the Andes continually intercept theſe vapours, and ſo occaſion continual rain. The Sierras being lower, intercept the vapours only from September to April, becauſe then the ſun being nearer the atmoſphere is lighter, and conſequently the vapours ſink lower.

In regard to this, there are two or three acts of Divine Providence which are highly obſervable. One is, that all countries throughout the world ſhould enjoy the great benefit of mountains placed here and there, at due and proper diſtances. According to the natural courſe of things, when the earth and waters were ſeparated, and ordered to their reſpective places, the earth would have been of one even ſurface. The ſeveral component parts thereof muſt have ſubſided according to their ſpecific gravities, and at laſt have

formed

formed a large, even ſpherical ſurface, every where equidiſtant from the centre of the globe. But that inſtead of this form, it ſhould jet out every where into hills and dales, is a manifeſt ſign of the ſpecial providence of a wiſe Creator. Another ſign of this is, that throughout the whole earth, the parts fartheſt from the ſea are the higheſt: an admirable contrivance both for ſupplying all places with water, and for carrying off the ſuperfluity of it.

And as the mountains themſelves are naturally diſpoſed to be drier than the low grounds, ſo nature has provided for them, a more plentiful ſupply of moiſture, unleſs for that very ſmall part of them which aſcends above the clouds and vapours. For beſide the fountains which water them continually, they have more rains and dews than the vallies. They are much more frequently covered by fogs; and by ſtopping and compreſſing the clouds, as well as condenſing them by their greater cold, they procure all the rain they want.

"But how were the mountains formed after the flood had diſſolved the terraqueous globe?" Probably thus. The ſmaller hills might eaſily be aggregated by the mere force of the water. But the mountains being of a denſer ſubſtance, ſeem to have been elevated from beneath, in a convex form, by the violent force of ſubterraneous wind, water, and fire, heaving them up, and ſcattering them abroad in ſo many protuberances. And if this was done before the ſubſtance of the ſtones became fixed and indurated, then it is no wonder that the external wind likewiſe ſhould leave ſo manifeſt tokens of its vehement impetuoſity, in the extent and outward figure of them. This gives an eaſy, natural account, for the innumerable fiſſures, chaſms, and diſruptions, whereby ſo many mountains are, as it were, ſawn aſunder, either acroſs or length ways. And hence many ſuch apertures in the mountains, are filled with a ſlimy matter which was afterwards indurated. In ſome of the mountains of Norway, this projects in a range, about an ell in breadth, betwixt the other ſtony ſtrata, through the whole length or bulk of the mountain, and from the variety of its colours, makes a very pleaſing appearance. Of theſe veins,

ſome

ſome conſiſt of marble or alabaſter, ſome of agate, ſome white, red, or blue ſtone, which eſpecially towards the ſea, where the rocks are bare, form many curious variegations. Hence likewiſe there remain on the ſurface many detached blocks and fragments, ſcattered not only in the vallies and creeks, but on the tops of the higheſt mountains. Many of theſe are of the bulk of a common houſe, and conſequently too ponderous, to have been raiſed to ſuch an immenſe height, by the hands or art of men.

But the largeſt mountains may have been formed in the following manner. The ſea-waters doubtleſs remained ſometime on the earth; and during that time the ſurface of the earth was the bottom of the ſea, where every thing paſſed in the ſame manner as paſſes at the preſent bottom of the ſea. Now the ſea has always had a flux and reflux, and that moſt violent under the equator, where likewiſe the earth's motion cauſes a greater centrifugal force than any where elſe. Suppoſe then the earth was at firſt quite round, yet its diurnal motion, with the flux and reflux of the ſea, would have raiſed by degrees the parts near the equator, by amaſſing there ſhells, mud and earth. And as this is performed daily, the water would carry at each time a ſmall quantity of matter, which afterwards ſinks to the bottom, and forms thoſe parallel ſtrata, which are every where found.

Thus in fact, on many ſhores the flux brings a great number of things along with it, and leaves them there. So that while it inſenſibly covers ſome lands, it abandons others, after adding thereto ſhells, earth and ſand, which gradually accumulating, make a part of the continent.

On a coaſt againſt which the ſea beats violently, it carries a little ſoil away at each tide. Yea, even where it is bordered with rocks, it wears them away by little and little. Theſe particles the water carry to a certain diſtance, where they ſink in the form of a ſediment, and form the firſt ſtratum, which will ſoon be covered by another, and ſo with more and more. Hence in time a mountain will be formed in the bottom of the ſea, entirely like what we ſee on the land.

Such eminences lying in the ſame direction with the

waves that produced them, form by degrees a chain of mountains. "But how come mountains whoſe top is compoſed of rock, to have only earth or ſand for their baſe, which may often be ſeen in the neighbouring plains, to a conſiderable diſtance?" We anſwer, the water firſt tranſported the ſand that formed the firſt layer at the bottom of the ſea. Afterward the more firm and weighty ſubſtances were attacked, and brought by the waters in an impalpable powder. And this powder of ſtone formed the rocks which now cover theſe eminences.

Theſe cauſes act with more force under the equator, as the winds are there more uniform, and the tides more violent: and accordingly the greateſt chain of mountains is near the equator. Thoſe of Africa and Peru are the higheſt we know, which after traverſing whole continents, ſtretch to very conſiderable diſtances, under the waters of the ocean. The mountains of the north are not equal to theſe. Moreover the number of iſles in the northern ſeas is inconſiderable, while there is a vaſt quantity under the torrid zone: and an iſland is no more than the top of a mountain.

It is then doubtleſs the general flux and reflux of the ſea, which has produced the greateſt mountains. But others we may aſcribe to currents, winds, and other irregular agitations of the ſea, which muſt by their various combinations, infinitely vary the direction of the tides. They are the ſmalleſt of all which owe their riſe to earthquakes, or other accidental cauſes.

But how ſhall we account for the formation of the iron mountain, near Taberg, in Sweden? It is ſituated in a mountainous part of the country, covered with ſand, near forty leagues from the ſea. It is an entire maſs of rich iron ore, the perpendicular height whereof is above four hundred feet, and its circumference three Engliſh miles. Oppoſite to it is a valley, through which flows a ſmall river. No ore is found beyond the foot of it, nor on the neighbouring plain, ſo that it appears as if the mountain had been artificially laid on the ſand. For it has no roots like other mountains, nor does its ſubſtance penetrate the ground. It has all over, many perpendicular and horizontal fiſ-

ſures,

ſures, filled with pure ſand: in the inner parts whereof bones of ſtags and other animals are found.

No hypotheſis hitherto advanced to account for the formation of mountains, will at all account for this. The bones found therein ſhew it was owing to ſome ruinous cauſe. But what that cauſe was, muſt in all probability ever remain a ſecret.

No leſs unaccountable are ſome of the mountains in Iceland, termed by the natives, Jokeler. From the tops of theſe continually flow large ſtreams of a thick, ſooty, ſtinking water. Theſe occaſion lakes which increaſe in bulk, and again diminiſh and change their appearance almoſt every day. Hence paths are ſeen in the ſand made by travellers that paſſed the day before. When followed, they lead to a large pond or lake, which obliges them to go two or three miles round, and then they come to the very path oppoſite to that which they were obliged to leave. But in a few days the lake is, as it were vaniſhed, and the uninterrupted path appears again.

7. A body that yields eaſily to the touch, and whoſe parts making but little reſiſtance againſt being divided, move among themſelves with great facility, is uſually termed a fluid. Liquids are a ſort of fluid which aſſume the figure of the veſſels they are contained in, and always keep their upper ſurface in a plain, parallel to the horizon. Such are water, oil, mercury, which are diſtinguiſhed from their fluids, by the paralleliſm of their ſurface, in conſequence of their weight, and the inteſtine motion of their parts all manner of ways. That they have ſuch a motion, plainly appears, from their diſſolving hard bodies. Put a piece of copper into a glaſs of aquafortis, and there is firſt an effervescence, then the copper diminiſhes, and at laſt diſappears. And what ſtrong waters are with regard to metals, other liquids are to other ſubſtances. Each of them is a diſſolvent, more or leſs, according to its component particles. Now it is plain that diſſolution ſuppoſes motion, and is the effect of it. There is therefore in all liquors an inteſtine motion, from which this effect reſults.

Water is a tranſparent liquid, capable of heat and cold, and of being rarefied into vapour. But it is not capable of being condenſed, by any method yet known. It is of itſelf without ſmell or taſte, and liable to putrefaction. It is heavier by many degrees than air, and inſinuates where air cannot enter. Theſe properties do unqueſtionably depend on the figure and texture of its parts. But theſe, after our moſt curious reſearches, it is not poſſible to know with certainty. Dr. Boerhaave ſays, no one ever yet ſaw a drop of pure water. It is never pure from ſalts. For all wawater contains air, and all air contains ſalts.

The particles of water are generally allowed to be round. This figure indeed is probably inferred from its fluidity. Allowing then the particles of it to be round, fluidity muſt be an eſſential property of all quantities and aſſemblages of it. For take any maſs of round bodies, (bullets for inſtance, pebbles, or the like) they will not cohere or reſt by one another without force, but will flow on every ſide, till they meet with ſuch reſiſtance from external bodies, or rather internal gravitation, as ſhall prevent farther motion.

The particles of water are unalterable, for paſſing into ſo many bodies, and through ſuch alternate extremes of heat and cold, if they had not preſerved their eſſential properties conſtantly, moiſture ſince the beginning of the world, muſt have very ſenſibly diminiſhed. But ſeeing no ſuch deficiency appears, and that ſprings, rains, and rivers, are as abundant now as they anciently were (as by the riſing of the Nile for many ages, among other reaſons may appear) we are to conclude though waters may be tranſplanted, they can neither be tranſmuted nor deſtroyed. And wherever removed they will make their appearance again when at liberty, in the ſame liquid ſtate as they were before.

The particles of water are exceeding ſmall: for they may be ſo divided from each other, that one ſquare inch of common water ſhall, when rarefied, fill a ſpace of 14000 ſquare inches. And it is computed that at leaſt 13000 particles of water may be held on the point of a needle. By this it appears, that what we call water is an aſſemblage of ſmall tranſparent globules,

bules, which are compoſed again of an infinite number of ſmaller particles or atoms of this elementary liquor.

Water ſeems to be diffuſed every where, and mixed with all bodies. Fire itſelf is not without it. Place ſalt of Tartar near the hotteſt fire, and it will imbibe water, and thereby in a ſhort time, conſiderably increaſe in weight. So a pewter veſſel with ice in it, brought up from a cold vault into the hotteſt room, in a dry ſummer-day, is immediately covered with little drops of water, which is gathered from the air, and condenſed by the coldneſs of the ice.

Indeed the quantity of water which is afforded by the dryeſt bodies is ſurpriſing. Oil of vitriol long expoſed to a violent fire, to ſeparate it from all its water, by only ſtanding a few minutes in the air, will afford as much as at firſt. Hartſhorn kept forty years, and turned as hard and as dry as any metal, ſo as to ſtrike fire with a flint, yet diſtilled in a glaſs veſſel, will yield an eight part of its quantity in water. Bones dried five and twenty years, and almoſt as hard as iron, have by diſtillation yielded half their weight in water. Yea, the hardeſt ſtones, ground and diſtilled, always afford a portion thereof. All animals and vegetables grow out of water and ſalts, and by putrefaction return to the ſame.

The chief properties of water are, 1. It is next to fire, the moſt penetrative of all bodies. So that a veſſel through which water cannot paſs, will contain any thing. Only ſome oils will paſs through thoſe wooden veſſels, which contain water. Not that their particles are more penetrative; but thoſe woods abound with rozin. This the oil diſſolves, and then makes its way through the ſpaces left thereby. Water alſo by degrees makes its way through all wood, and is only retainable by glaſs and metals. It finds its way where air cannot, as through leather, which air cannot penetrate. Again. Air may be retained in a bladder; but water oozes through. Yea, experiments ſhew, it will paſs through pores ten times ſmaller than air will. By this very quality it is fitted to enter into the compoſition of all bodies, animal, vegetable, and foſſil; with this peculiar circumſtance, that by a gentle heat it is

ſeparable

ſeparable from them again. By this, joined with its ſmoothneſs, it is fit to convey the nutritive matter of all bodies. Paſſing ſo readily, it never ſtops up the pores, but leaves room for the following ſupplies. And yet, 2. Water, which ſo eaſily ſeparates from moſt bodies, firmly coheres with ſome: yea, binds them together in the moſt ſolid maſſes. So mixed with aſhes, it gives the utmoſt firmneſs. The aſhes, for inſtance, of an animal, wrought up with pure water into a paſte, and baked with a ſtrong fire, grows into a coppel, which bears the utmoſt heat of a refiner's furnace. It is in truth, by the glutinous nature of water alone that our houſes ſtand. For take this out of wood, and it becomes aſhes; out of tiles, and they become duſt.

Indeed all the ſtability and firmneſs in the univerſe are owing in part to water. Thus ſtone would be incoherent ſand, did not water bind it together. And thus of water and clay we make earthen veſſels, of the utmoſt hardneſs and cloſeneſs. And theſe, though appearing perfectly dry, yield when diſtilled, an incredible quantity of water. The ſame holds of metals, parings or filings, which by diſtillation yield water plentifully. Yea, the hardeſt ſtones, ſea-ſalt, nitre, vitriol, are hereby ſhewn to conſiſt chiefly of water.

Hence we learn that the component particles of water are, 1. Infinitely ſmall; whence their penetrative power. 2. Exceeding ſmooth and ſlippery; hence their fluidity, and eaſy ſeparation from other bodies. 3. Extremely ſolid. 4. Perfectly tranſparent. 5. Hard, rigid, and inflexible: as appears from the abſolute impoſſibility of compreſſing them.

Salts melted in water, do not fill the veſſel in proportion to their bulk. It follows, that there are ſpaces between the particles of water, to admit thoſe of the ſalt. Hence alſo we gather, that the watry particles are extremely ſolid and inflexible, ſince notwithſtanding thoſe ſpaces, no power can compreſs, or force them nearer each other.

8. When the particles of nitre that float in the air, wedge the particles of water together, they become ice. The air lodged in the pores of the water, is then greatly expanded. Hence the water is lighter than before;

before; but at the ſame time it is leſs tranſparent: perhaps becauſe the paſſage of light is hindered by the interpoſal of theſe nitrous particles.

It is obſervable, 1. That all liquids, except oil, dilate in freezing and grow lighter. Nay, even after they are thawed, they are conſiderably lighter than before: 2. That water will not freeze in vacuo: 3. That water which has been boiled does not readily freeze: 4. That water covered with oil of olives does not freeze readily; covered with nut oil, not at all: 5. That nut oil, oil of turpentine and ſpirits of wine will not freeze at all: 6. That frozen water is covered with wrinkles, ſomething like rays drawn from a centre to the circumference.

Though fluids are dilated near a tenth of their length, metal are ſhortened by froſt. If veſſels made of metals, however thick and ſtrong, be filled with water, cloſe ſtopped, and expoſed to froſt, the water will burſt the veſſels. A ſtrong barrel of a gun, thus filled and ſtopped, will rend the whole length.

Dr. Plot obſerves, that rivers are always found to freeze firſt at their bottom. The ſame is obſerved by watermen in the Thames, who not only feel it at the bottom with their poles, ſome days before the ſurface is froze over, but ſee it riſe up from the bottom, ſo as to dart up in pieces edgeways, half a foot, ſometimes a foot above the ſurface. In this poſture it continues a little time, and then turning flat upon the water, ſwims along the ſtream, till it meets with other pieces, which if the froſt continues, all harden into one, till the river is froze over.

"In a part of the Thames, where there was very little ſtream, I found the water, (ſays Dr. Hale) in a cold morning, froze one fifth of an inch thick, under which I ſaw a bed of ice at the bottom. Breaking away ſome of the upper ice, I took up ſome of the lower ice, which was about half an inch thick. It adhered cloſe to the bottom, where the ſtones and ſand were incorporated with it. When it freezes to a conſiderable thickneſs, it will raiſe up with it from the bottom, the fiſhermen's oſier wheels, although they are ſunk down with ſtones or bricks tied to them.

"Standing

" Standing waters indeed freeze firſt at top, becauſe they are coldeſt there: whereas in a ſtream the upper and lower waters being continually blended together, are equally cold; and the upper water mean time having more motion, cannot freeze ſo ſoon. But here, where the motion of the water was ſo ſmall, its ſurface was froze as well as the bottom, though not ſo thick: whereas the mean river, where its motion was greater, was not froze over, though cakes of ice were continually riſing from the bottom."

It has been commonly ſuppoſed, that fluids not only dilate, but evaporate by cold. And this has long paſſed for an inconteſtible truth. Yet it is altogether a miſtake. From later experiments it undeniably appears, 1. That cold does not increaſe, but leſſen the evaporation of water, if it be not expoſed to the agitation of the air: 2. That the evaporation of water depends on an inteſtine motion, which it preſerves as long as it is liquid, and that the air only contributes thereto, by continually tranſporting the particles detached from the ſurface, and thereby giving other particles room to diſengage themſelves: 3. That frozen water does not evaporate at all, if it be kept from the agitation of the air: 4. That the diminution obſerved in ice expoſed to the open air, is not from any evaporation, but is the effect of a fine raſping by the wind, rubbing againſt it and carrying off its finer particles. And what is thus detached from ice is only a very fine duſt, not more different from ice than the duſt of freeſtone, cut from the ſtone itſelf.

This duſt carried by the wind produces intenſe cold. Nor is it always inviſible. The air near Hudſon's Bay is often filled with particles of ice, fine as hairs, and ſharp as needles; which if they ſtrike againſt the hands or face, pierce the ſkin, and occaſion painful bliſters.

The natural ſtate of this globe ſeems to be in an intermediate degree between heat and cold. And this natural warmth of the earth is what ſecures many ſprings from being frozen: the froſt in England ſeldom penetrating the earth, more than fourteen inches below the ſurface. Even in Sweden bubbling ſprings do not freeze at all, while the ſtanding waters freeze three ells deep.

In

In the lakes of Sweden the ice often cracks, with a rupture nine or ten feet deep, and many leagues long, and with a noiſe like cannon. Hereby the fiſhes get air, ſo that few of them are deſtroyed. In Moſcow the earth is often cleft by the froſt, a foot broad and many yards long. In the mountains of Switzerland, there are vaſt maſſes of ice, which have lain there for many centuries. At certain times theſe crack, and by thoſe cracks one may gueſs at the immenſe thickneſs of them: ſome of the cracks being three or four hundred ells deep, though none of them have ever gone through the whole thickneſs of the ice.

We need not then be ſurpriſed, at the effects of ſevere froſt on trees and other vegetables. How theſe are hurt in hard winters is eaſily underſtood, if we conſider, that water when frozen, takes up more ſpace than it did before: that all trees, eſpecially thoſe that ſhed their leaves, drink in a large quantity of moiſture in ſummer, and that the veſſels of ſmall twigs are larger in proportion than thoſe of the trunk, and conſequently contain more moiſture. It follows, that being ſurpriſed by a hard winter, before their juices are diminiſhed, or changed into a glutinous nature, which does not ſo eaſily freeze; the veſſels of the tree muſt neceſſarily burſt. Conſequently their juice muſt be extravaſated, and ſo cauſe, as in animals, the death of the tree, by a kind of bleeding, which nothing can ſtop.

In the great froſt in 1683, oaks, aſhes and walnut-trees were cleft in two, and frequently with a terrible noiſe, and not only their bodies, but their branches and roots alſo. In 1708, the froſt was almoſt through all Europe, except Scotland and Ireland. All the orange-trees and olives in Italy, Provence, and many other countries periſhed, and all the walnut trees in France, with an infinity of other trees. In England moſt of the bay-trees, hollies, roſemary, and even furze periſhed. The ſap alſo of wall-trees ſtagnated in the branches, and produced diſorders reſembling chilblains. And the very buds of the finer trees were quite killed, and turned into a kind of mealy ſubſtance.

In 1728, toward the end of November, the wind blew exceeding cold, followed by ſo heavy a ſnow, as in one night broke off large arms of many evergreen trees. At this time alſo, there was a great number of large trees diſbarked. Two Weſt India plane-trees, in particular, in the phyſic garden at Chelſea, which were near forty feet high, and a fathom in circumference, were diſbarked almoſt from the bottom to the top, on the weſt ſide of the trees. And it was obſervable, that whatever trees were diſbarked, it was on the weſt or ſouth-weſt ſide.

On the fourteenth of December, 1759, there was at Peterſburg, the moſt exceſſive cold weather that ever was known, even to 205 degrees of De Liſle's thermometer. At that time Profeſſor Braun repeated Fahrenheit's experiments, in order to produce exceſſive cold by means of ſpirit of nitre combined with ſnow. He ſaw with ſurpriſe, the quickſilver in the other thermometer deſcend even to 470 degrees: there the quickſilver remained fixed in the open air, for the ſpace of a quarter of an hour, and did not begin to riſe, till it was carried into a warm room. He repeated the ſame experiment, firſt with the ſame, and then with another thermometer, with the ſame ſucceſs. But as Mr. Braun had not broken the glaſſes, he could only at that time form a conjecture. On the 17th he produced again cold equal to that of the 14th, and communicated his diſcovery at a meeting of the Academy. On the 25th of December in the morning, between nine and ten, De Liſle's thermometer was at the 199th degree of cold, and Mr. Braun, as well as Profeſſor Æpinus, repeated this experiment. As ſoon as the former obſerved the quickſilver immoveable in the thermometer, he broke the glaſs, and found the quickſilver frozen, but not entirely: Mr. Æpinus' thermometer fell with extreme rapidity, almoſt to the 500th degree, and in breaking the glaſs from below, he found the quickſilver contained in it abſolutely frozen. Both the gentlemen found, that the quickſilver, thus rendered ſolid, bore hammering and extenſion, like other metals; but being expoſed to the open air, it recovered its former fluidity in a little time.

Mr.

Mr. Æpinus went farther, to examine the quickſilver when it was made ſolid. He poured quickſilver into a glaſs tube, as thick as one's finger, cloſed at the bottom, but open at top.

The quickſilver in this cylinder, which was about one inch and half long, froze in three quarters of a minute; and became ſolid, perfectly reſembling other metals. Mean time it continually contracted its ſurface, which was at firſt pretty high, ſunk very low, and the cylinder of frozen quickſilver ſunk to the bottom of the fluid quickſilver. We know the contrary happens to water frozen and other fluids, which extend as they become ſolid, and their ice ſwims in the fluid matter, of which they were produced.

The bodies of ice in the northern ſeas, near Hudſon's Bay are ſurpriſing: ſome of them are immerſed a hundred fathoms or more, under the ſurface of the ocean. They ſtand a fifth or ſixth part above, and are three or four miles in circumference. Theſe floating mountains owe their durable nature to a cauſe not uſually obſerved; that is, to their not being common ice, but the ice of ſea-water. If a phial of ſea-water be expoſed to the air in froſty weather, till flakes of ice are formed therein, and then ſet in a warm room, ſtill the flakes will remain a long time undiſſolved, and if they are taken out, and expoſed at a ſmall diſtance to the fire, they will not run into water, as common ice does; but will by degrees evaporate, leaving only a little white ſalt. It is eaſy then to conceive, that the immenſe maſſes of this ice found in the Northern Seas, will continue undiſſolved throughout the year, and at the return of the freezing ſeaſon, grow larger and larger every year, by the freezing of more ice about them.

On the contrary there are ſome waters, which will not freeze at all. The lake Neſs in Scotland never freezes, be the winter ever ſo ſevere. Yea, while every thing round is frozen, its water runs ſmoking for ſix miles down the river into which it is diſcharged; and from this ſmoke there riſes a ſort of fog, which overſpreads the country, for ſeveral miles. Near the

lake

ake is a mountain, on the ſummit of which there is another lake, which is always full, ſummer and winter. Due weſt from the river, there is another lake, two miles long and ſix broad. The middle of this is ſometimes dry, and then plainly appears to have been once an inhabited country. There are many tumuli to be ſeen under water, one of which is acceſſible at low water. And in this urns have been found, which leave no room to doubt of their having been burial places.

There are likewiſe in Scotland other lakes, which freeze only at peculiar ſeaſons. A little lake in Stratherick, never freezes over, be the froſt ever ſo ſharp, till February. But after the firſt part of this month, a ſlight froſt will freeze it over in a night's time. There are alſo two other remarkable lakes in the ſame country. The one Loch Monan, which is conſiderably large, obſerves the ſame rule, freezing over in February with a ſlight froſt, but never before, be the ſeaſon ever ſo rigorous. The other in Straglaſh has a contrary quality. It lies between two high hills, and is itſelf conſiderably above the level of the reſt of the country. This freezes continually, having ice in the middle, even in the hotteſt ſummer months, while the ſun, by reflection from the hills on each ſide, gives a very conſiderable heat. There are many other lakes in the neighbouring country which yet have no ſuch property: ſo that this, and the property of the two other lakes, muſt be owing to ſome peculiar cauſe. The herbage about the ſides of the laſt lake mentioned, has a kind of perpetual ſpring, which continues throughout the whole year, and is much eſteemed by the country people, for feeding cattle in one month, more than the beſt land in the country will do in two. The lake is very deep, and the water does not manifeſt any particular quality.

9. Rain and ſnow which riſe in vapours, both from the earth and waters, deſcending on hills, ſink through the earth, till they meet with a bed of clay or ſtone. This retains the water and gathers it together, in a larger or ſmaller baſon, till running over the edge, it

makes

makes itſelf a way, and riſes in a fountain. Hence iſſues a rivulet, many of which joining together, conſtitute a river, which continues its courſe, till it empties itſelf into the grand receptacle of water, the ſea.

But it has been aſked, "Is there a ſufficient quantity of vapours raiſed, in the ordinary courſe of nature, to ſupply the demand of fountains and rivers?" We anſwer, there is abundantly ſufficient, from the ſurface of the ſea alone, leaving the earth out of the account. For it has been ſhewn by clear experiments, 1. That water ſalted to about the ſame degree as ſea-water and expoſed to heat equal to that of a ſummer's day, did from a circular ſurface, eight inches in diameter, evaporate ſix ounces in 24 hours. If ſo, the thickneſs of a ſkin of water, evaporated in two hours, is the 53d part of an inch. But were it only a 60th, it would exhale the tenth of an inch in two hours. And on this principle every ten ſquare inches of the ſurface of water, yield in vapour a ſquare inch of water daily: each ſquare foot half a pint: every ſpace of four feet ſquare, a gallon: a mile ſquare 6914 tons: a quantity abundantly ſufficient to furniſh, both dews, rains, ſprings, and rivers. So that we need not have recourſe for ſupplies to the great abyſs, whoſe ſurface, at high water, is ſurmounted ſeveral hundred feet, even by ordinary hills; and ſome thouſands, by thoſe vaſt mountains, from whence the largeſt rivers take their courſe.

Nevertheleſs we may allow a different riſe to thoſe ſprings, which ebb and flow with the ſea; as likewiſe to thoſe lakes whoſe water is ſalt, and which have ſea-fiſh in them, although they have no communication with any ſea, by any viſible paſſage.

To explain this a little more at large. It is evident from experience, that a vapour is perpetually riſing from the ſea, rivers, and lakes. The winds carry this vapour through the atmoſphere, in the form of a cloud or miſt. When it meets with a colder air, or is ſtopt by mountains, it condenſes, and falls to the earth. As it falls, it finds ſeveral chinks and crannies, through which it inſinuates into the mountains, and lodges there, till increaſing its ſtore, it burſts out and takes the name of a fountain.

That

ake is a mountain, on the ſummit of which there is another lake, which is always full, ſummer and winter. Due weſt from the river, there is another lake, two miles long and ſix broad. The middle of this is ſometimes dry, and then plainly appears to have been once an inhabited country. There are many tumuli to be ſeen under water, one of which is acceſſible at low water. And in this urns have been found, which leave no room to doubt of their having been burial places.

There are likewiſe in Scotland other lakes, which freeze only at peculiar ſeaſons. A little lake in Stratherick, never freezes over, be the froſt ever ſo ſharp, till February. But after the firſt part of this month, a ſlight froſt will freeze it over in a night's time. There are alſo two other remarkable lakes in the ſame country. The one Loch Monan, which is conſiderably large, obſerves the ſame rule, freezing over in February with a ſlight froſt, but never before, be the ſeaſon ever ſo rigorous. The other in Straglaſh has a contrary quality. It lies between two high hills, and is itſelf conſiderably above the level of the reſt of the country. This freezes continually, having ice in the middle, even in the hotteſt ſummer months, while the ſun, by reflection from the hills on each ſide, gives a very conſiderable heat. There are many other lakes in the neighbouring country which yet have no ſuch property: ſo that this, and the property of the two other lakes, muſt be owing to ſome peculiar cauſe. The herbage about the ſides of the laſt lake mentioned, has a kind of perpetual ſpring, which continues throughout the whole year, and is much eſteemed by the country people, for feeding cattle in one month, more than the beſt land in the country will do in two. The lake is very deep, and the water does not manifeſt any particular quality.

9. Rain and ſnow which riſe in vapours, both from the earth and waters, deſcending on hills, ſink through the earth, till they meet with a bed of clay or ſtone. This retains the water and gathers it together, in a larger or ſmaller baſon, till running over the edge, it makes

makes itſelf a way, and riſes in a fountain. Hence iſſues a rivulet, many of which joining together, conſtitute a river, which continues its courſe, till it empties itſelf into the grand receptacle of water, the ſea.

But it has been aſked, "Is there a ſufficient quantity of vapours raiſed, in the ordinary courſe of nature, to ſupply the demand of fountains and rivers?" We anſwer, there is abundantly ſufficient, from the ſurface of the ſea alone, leaving the earth out of the account. For it has been ſhewn by clear experiments, I. That water ſalted to about the ſame degree as ſea-water and expoſed to heat equal to that of a ſummer's day, did from a circular ſurface, eight inches in diameter, evaporate ſix ounces in 24 hours. If ſo, the thickneſs of a ſkin of water, evaporated in two hours, is the 53d part of an inch. But were it only a 60th, it would exhale the tenth of an inch in two hours. And on this principle every ten ſquare inches of the ſurface of water, yield in vapour a ſquare inch of water daily: each ſquare foot half a pint: every ſpace of four feet ſquare, a gallon: a mile ſquare 6914 tons: a quantity abundantly ſufficient to furniſh, both dews, rains, ſprings, and rivers. So that we need not have recourſe for ſupplies to the great abyſs, whoſe ſurface, at high water, is ſurmounted ſeveral hundred feet, even by ordinary hills; and ſome thouſands, by thoſe vaſt mountains, from whence the largeſt rivers take their courſe.

Nevertheleſs we may allow a different riſe to thoſe ſprings, which ebb and flow with the ſea; as likewiſe to thoſe lakes whoſe water is ſalt, and which have ſea-fiſh in them, although they have no communication with any ſea, by any viſible paſſage.

To explain this a little more at large. It is evident from experience, that a vapour is perpetually riſing from the ſea, rivers, and lakes. The winds carry this vapour through the atmoſphere, in the form of a cloud or miſt. When it meets with a colder air, or is ſtopt by mountains, it condenſes, and falls to the earth. As it falls, it finds ſeveral chinks and crannies, through which it inſinuates into the mountains, and lodges there, till increaſing its ſtore, it burſts out and takes the name of a fountain.

That

That this is really the caſe, will eaſily be allowed, by all who ſeriouſly conſider. 1. That the vapours riſing from the ſea, are more than ſufficient to ſupply both the ſurface of the earth, and the rivers with water. 2. That the mountains by their particular ſtructure arreſt the vapours that float in the atmoſphere, and having collected them in their reſervoirs, diſmiſs them again through their ſides, either in perpetual or intermitting currents.

With regard to the firſt, it has been ſhewn, that every ten ſquare inches of the ſurface of the ſea, yields a ſquare inch of water daily; every ſquare mile 6914 tons: and purſuing the ſame proportion, every ſquare degree (or ſixty nine Engliſh miles,) will yield 33 millions of tons. Now if we ſuppoſe the Mediterranean to be 40 degrees long, 4 broad at a medium, (which is the leaſt we can ſuppoſe) its ſurface will be 160 ſquare degrees: from whence there will in ſummer evaporate daily 5280 millions of tons.

The Mediterranean receives water, (to ſay nothing of ſmall and inconſiderable ſtreams) from eight large rivers, the Iberus, the Rhine, the Po, the Danube, the Neiſter, the Boryſthenes, the Tanais and the Nile. Now ſuppoſe each of theſe conveys ten times as much water to the ſea as the Thames. The Thames has been ſhewn to pour daily into the ſea 203 millions of tons. Therefore all thoſe rivers will produce 1827 millions of tons. But this is little more than one third of the quantity daily evaporated from the ſea. How prodigious a quantity then remains for rains and all other purpoſes?

Let us obſerve, ſecondly, how the mountains arreſt, and collect theſe vapours, and then diſcharge them in ſprings.

The tops of mountains in general abound with inequalities, cavities, grottos and gaping cells. The floating vapours, are ſtopt by theſe and by their pointed ſummits, and being condenſed thereby, precipitate in water, eaſily penetrate through ſand and lighter earth, and gather in baſons of clay or ſtone, till they overflow and work a paſſage through the ſide of the mountain.

And

And yet we need not deny, that ſome ſprings may ariſe from the ſea, or the great abyſs: thoſe in particular, which at all times afford the ſame quantity of water. Some of theſe are found in almoſt every country. There is one near Upminſter in Eſſex; which in the greateſt droughts, and when all the brooks are dried up, is little, if at all diminiſhed. And in the wetteſt ſeaſons, it is not increaſed, unleſs violent rain falling into it, or running into it from the higher grounds, raiſe it for a day, or a few hours.

As to the manner how the water riſes in ſuch ſprings it may eaſily be repreſented, by putting a ſmall heap of ſand in a baſon, and then pouring in water. Here the ſand will repreſent the dry land, and the water the ſea round about it. And as the water in the baſon riſes, to or near the top of the heap, juſt ſo do the waters of the ſea riſe, to the top of the land with which it communicates.

10. Some think the earth entirely covered the ſea, till at the deluge the fountains of the great deep were broken up. And it is highly probable, there is ſtill an abyſs of waters within the earth, which has an uninterrupted communication with ſome part of the outward ſea.

The immediate cauſe of the deluge, was probably that comet, which (as Mr. Whiſton ſhews) paſſed toward the ſun, juſt before the earth, on the firſt day of the deluge. The conſequence of this muſt be, that when it came below the moon, it would raiſe a vaſt and ſtrong tide, both in the waters that were on the antediluvian earth, and alſo in the great abyſs, which was under the cruſt of the earth. This tide muſt increaſe all the time that the comet was approaching toward the earth; and would be at its greateſt height, when the comet was at the leaſt diſtance from it. By the force of this internal tide, as well as by the attraction of the comet, the abyſs which was nearly round before, would then become oblong. And this muſt immediately extend, and then burſt the incumbent cruſt. And thus, according to the expreſſion of Moſes, the fountains of the great deep were broken up.

Again. As the ſame comet for a conſiderable time involved

involved the earth in its atmoſphere, it muſt have loſt a vaſt quantity of its vapours, moſt of which would fall on the earth in violent rain. And thus the windows of heaven were opened. To remove this vaſt orb of water, he ſuppoſes a mighty wind to have riſen, which dried up ſome, and forced the reſt into the abyſs again, through the clefts by which it came up. Only part of it ſtayed in the channel of the ocean, now firſt made to receive it, and in the leſſer cavities, placed up and down on the ſurface of the globe.

The preſent diſtribution of the waters and the dry land, though it may ſeem rude and undeſigned to a careleſs view, yet is admirably well adjuſted to the uſe and conveniences of our world. In the firſt place, they are ſo diſtributed all the world over, that there is a juſt equipoiſe of the whole globe. The northern balances the ſouthern ocean; the Atlantic, the Pacific ſea. The American dry land is a counterpoiſe to the European, Aſiatic, and African. In the next place, the waters are ſo admirably well placed about the globe, as to afford ſufficient vapours for clouds and rain, to temper the cold of the northern and ſouthern air, to mitigate the heats of the torrid zone, and to ſupply freſh waters to fountains and rivers. Nay, ſo abundant is this great bleſſing, that we have more than a bare ſufficiency, even a ſurpluſage of this uſeful creature: and yet ſo well ordered, as not to drown the earth, not to ſtagnate, putrify or annoy its inhabitants; but to glide gently through convenient channels back again to its grand fountain, the ſea; and many of the rivers through ſuch large tracts of land, and to ſuch prodigious diſtances, that it is a wonder the fountain ſhould be high enough, or the ſea low enough for ſo long a conveyance. Witneſs the Danube and Wolga in Europe, the Nile and Niger in Africa, the Ganges and Euphrates in Aſia, with the Amazon's river and Rio de la Plata in America. No accidental currents or alterations of the waters themſelves, no art or power of man, nothing leſs than the power of the Almighty could ever have made or found, ſo long and commodious declivities and channels, for the paſſage of thoſe waters.

11. The

11. The largeſt rivers of Aſia, are, the Hoanho, in China, which is eight hundred and fifty leagues in length: the Jeniſca of Tartary, about eight hundred leagues in length, from the lake Selinga to the Icy Sea: the Oby in Sibera, of near eight hundred leagues, running from the lake of Kila into the northern ſea, the Amour in Eaſtern Tartary, whoſe courſe is about five hundred and ſeventy-five leagues, from its ſource to its entrance into the ſea of Kamtkatſka: the Kiam in China, five hundred and fifty leagues in length. The Ganges, one of the moſt noted rivers in the world, is about as long as the former; it is viſited annually by ſeveral hundred thouſand pilgrims, who pay their devotions to the river as to a god; for ſavage ſimplicity is always known to miſtake the bleſſings of the Deity for the Deity himſelf. Next to this may be reckoned the celebrated river Euphrates: this riſes from two ſources northward of the city of Erzerum in Turcomania, and unites about three days journey below the ſame; from whence, after performing a courſe of five hundred leagues, it falls into the gulf of Perſia. The river Indus is extended, from its ſource to its diſcharge into the Arabian ſea, four hundred leagues.

The largeſt rivers of Africa, are the Senegal, which runs a courſe of eleven hundred leagues: and the celebrated river Nile, ſaid to be nine hundred and ſeventy leagues from its ſource in Upper Ethiopia, to its opening into the Mediterranean ſea.

This river, which the natives call Abava, that is, the father of rivers, riſes firſt in Sacala, a province of the kingdom of Goiama, the moſt fruitful in all Abyſſinia. In the eaſtern part of this province, on the declivity of a mountain, are two ſprings, each about two feet diameter, a ſtone's caſt diſtant from each other, which are the real ſource of this celebrated river. Its waters, after the firſt riſe, run eaſt about a muſket-ſhot; then turning to the north, continue hid in the graſs and weeds, for about a quarter of a league, and diſcover themſelves for the firſt time among ſome rocks, a pleaſing ſight to thoſe who have read the fabulous accounts of the ancients. It flows thence with a very ſmall ſtream, but ſoon receives ſuch an increaſe from various

various rivulets, that not above three days journey from its ſource, it is near a mile broad. After running nine or ten leagues farther, it enters the lake of Dambia. It croſſes this at one end, with ſuch rapidity, that the waters of the Nile may be diſtinguiſhed through the whole paſſage, which is ſix leagues. Fifteen miles farther it ruſhes from the top of a high rock, and forms one of the moſt beautiful caſcades in the world. The fall of this mighty ſtream from ſo vaſt a height, makes a conſiderable noiſe. Yet the neighbouring inhabitants are not deaf, but hear juſt as well as others. After this cataract, the Nile again collects its ſcattered ſtream, and flows on through various nations. Hence we may learn, that it is impoſſible to arrive at the ſource of the Nile, by tracing its chamel from the mouth, there being ſo many cataracts in the way, which no veſſel can paſs.

In Abyſſinia, from June to September, there is no day without rain. Now the Nile receives in its courſe all the brooks, rivers, and torrents, which flow from the Abyſſinian mountains. Theſe neceſſarily ſwell it above the banks, and fill the plain of Egypt with the inundation. This comes regularly in the month of July, that is, three weeks after the beginning of the rains in Ethiopia.

The water of the Nile is ſo delicious, that the Turks excite themſelves to drink of it by eating ſalt. When the Egyptians leave their country, they ſpeak of nothing but the pleaſure they ſhall find at their return, in drinking the Nile water. All thoſe who have taſted of it, allow, that they never met with the like in any other place. In truth, when one drinks of it the firſt time, it ſeems (ſays Maſerier) to be ſome water prepared by art. It has ſomething in it inexpreſſibly agreeable and pleaſing to the taſte. But to ſome, it appears to have too much ſweetneſs. It is likewiſe ſalutary in the higheſt degree. Drink it in what quantities you will, and it never incommodes you.

It ſeems peculiar to the water of the Thames, that in eight months time it acquires a ſpirituous quality, ſo as to burn like ſpirits of wine. Even when it ſtinks, it is not unwholeſome: men who were obliged to hold their

their noſes, yet drank of it all the way to the Eaſt-Indies, and found no inconvenience. If you take out the bung from any caſk that ſtinks, and let the air come in, it will be ſweet in twenty-four hours. If you take a broom-ſtick, and ſtir it well, it will be ſweet in four or five hours. It caſts a black lee to the bottom, which remixing with it, cauſes a third or fourth fermentation, after which it ſtinks no more. But though Thames water does not putrify when it ſtinks, moſt other water does, and is at that time very dangerous to drink.

The cataracts of the Nile are probably leſs remarkable than that of Niagara, in Canada. The fall of this is about ſix leagues from Fort Niagara. The whole courſe of the river for two leagues and a half below the great fall, is a ſeries of ſmaller falls, one under another. The rocks of the great fall croſs the river in almoſt a ſemicircle. Above the fall in the middle of the river, and parallel with the ſides of it, is an iſland above four hundred yards long. The lower end of this iſland is juſt at the perpendicular edge of the fall. On both ſides of this iſland runs all the water that comes from the lakes of Canada, which indeed are rather ſeas than lakes, receiving many large rivers. When the water approaches the iſland, it runs with an amazing ſwiftneſs, and before it comes to the fall, is quite white, and in many places is thrown high into the air. Looking up the river from the fall, you ſee it is exceeding ſteep, reſembling the ſide of a hill. When this vaſt body of water comes to the fall, it throws itſelf down perpendicular. To ſee this ruſh headlong down ſo prodigious a precipice, ſtrikes the beholder in a manner not to be expreſſed.

It falls one hundred and thirty-ſeven feet. When the water is come down to the bottom, it leaps back to a great height in the air: at a little diſtance it is white as ſnow, and boils like a cauldron. The noiſe of it in fair weather is heard fifteen leagues, yea, many times at Niagara. From the place where the water falls, abundance of vapour riſes, reſembling a very thick ſmoke. When it is calm this riſes high in the air. If you go into this vapour, in a few minutes you will

will be as wet as if you had been under water. In a calm morning, you may ſee it riſing in the air, at the diſtance of many leagues. And a perſon unuſed to it, would be apt to think, that all the foreſts threabouts were on fire.

But of all parts of the world, America ſupplies the largeſt rivers. The foremoſt of theſe is the great river of Amazons, which from its ſource in the lake of Lauricocha, to its diſcharge into the weſtern ocean, performs a courſe of more than twelve hundred leagues. The breadth and depth of this river are anſwerable to its vaſt length; and where its width is more contracted, its depth is augmented in proportion. Next to this is that of St. Lawrence, in Canada, which after a courſe of nine hundred leagues, pours its collected waters into the Atlantic ocean. The river Miſſiſippi is more than ſeven hundred leagues in length. The river Plata is more than eight hundred. The river Oroonoko is ſeven hundred and fifty-five leagues in length, from its ſource to its diſcharge into the Atlantic Ocean.

The glory of other rivers increaſes in proportion to the length of their courſe. With the Rhine it is quite the reverſe. For ſome hundred miles it pours on with a vaſt force. But at Fort Scheneken it divides, and one half of its waters takes the names of Wahall. The Yſſel robs it of another part, a little above Arnheim. About twenty miles lower, at the town of Duerſtadt, it ſeparates again. Here its principal branch takes a new name, and is called the Leck. The poor, little, ſtripped rivulet turns to the right, retaining ſtill the old name of Rhine, and paſſes on to Utretcht, where it is divided a fourth time. There the Vetcht breaks off, and the little thread of water, ſtill called the Rhine, paſſes quietly to Worden. At length it comes to Leyden, and faintly finiſhes its courſe, by loſing the ſmall remainder of its waters in two or three canals.

The cauſe of the Rhine's fate is well known. It was an earthquake which ſhook the Downs, in the ninth century, and filling the mouth of this river, forced it

to

to return, and ſeek a new paſſage. The Leck was then ſcarce worth notice: but the waters of the Rhine, which were driven back, ſwelled and deepened its channel: and the entrance of the ſea has been ever ſince ſhut againſt the ancient courſe of the Rhine. It is ſuppoſed, that Zealand was then divided into the ſeveral iſlands we ſee now: and that thoſe lands, woods, and meadows, which were between Amſterdam and the Texel, were overflowed and covered with the waters ſtill remaining, and known by the name of the Zuyder ſea.

The lake Baiacal, in Siberia, is the greateſt freſh water lake yet diſcovered. It extends in length above five hundred leagues, and is from twenty-five to eighty leagues in breadth. It is every where deep and navigable. The water is extremely clear, and abounds with fine fiſh. It receives abundance of rivers, but none runs out of it, beſides one, the Angara.

Salt lakes are common in many parts of Siberia. Some contain a pure, white ſalt, fit for uſe, which in ſummer is cryſtalized by the heat of the ſun, and forms a cruſt on the top of the lake. Springs of ſalt-water ſometimes riſe in the midſt of freſh water. One of theſe riſes through a rock, in the bed of the river Angara. Thirty leagues above this, there is a hill thirty fathom high and two hundred and ten long, conſiſting entirely of rock ſalt. There are ſome lakes, which were freſh ſome years ſince, but are now ſalt: ſome have by degrees dried up; others appear, where formerly it was dry ground. And ſome of theſe, which at firſt had no fiſh, are now plentifully ſtocked therewith. The natives ſay, ducks and other birds that lives upon fiſh, carry their eggs from one lake to another.

Three leagues eaſt of Damaſcus is a lake ten or twelve leagues long, and five or ſix broad. This continually receives the waters of many rivers; yet never overflows its banks. Above thirty leagues from it, there is a river, which is called the Dog-river. From under a large, vaulted rock, through an open-

ing

ing twelve or fifteen feet high, and twenty or twenty-five broad, iſſues continually a vaſt body of water, which gives riſe to this river. And it is the common opinion, that this body of water, comes from the lake, through a ſubterraneous channel: which is the more probable, becauſe the water of the lake and the river have the ſame qualities, and contain the very ſame ſorts of fiſh, being cold, hard, and remarkably unwholeſome.

Far different from this, is the water which riſes out of the ground, throughout the vaſt ſandy deſerts of the Mongal Tartars. Wherever you dig, there riſes freſh water. Were it not for this, they muſt have been altogether uninhabited, either by man or beaſt. It ſeems theſe ſprings are produced by the rains and melted ſnow in the ſpring. For the water ſinking in the ſand is thereby prevented from exhaling by the heat of the ſummer ſun, which muſt be very ſcorching in theſe deſerts, wherein there is not the leaſt ſhade to be found.

Beſides the rivers which run upon the ſurface of the earth, there are many which hide themſelves in its bowels, and run in ſubterraneous ducts, till they diſcharge themſelves into the ſea. A remarkable one of this kind has been diſcovered on the coaſt of Languedoc. There are alſo ſeveral of this ſort on the coaſt of Croatia, over-againſt Venice.

Thus does the All-wiſe Creator ſhower down his treaſures on the ſummits of the mountains, which afterwards diffuſe their refreſhing ſtreams over the plains below, give life and verdure to the trees and herbs, and beautify and enrich the whole earth. At the ſame time we ſee the communication between thoſe parts of nature, that before ſeemed to have no relation to each other. Indeed all nature is linked together by one law of harmony, which ſufficiently proves it to be the work of one wiſe and gracious Author.

How delightful an object is a large and majeſtic river! How graceful an appearance does it make in the

the works of nature! Conſider its progreſs. At firſt it is but a vein of water, ſtreaming from ſome hill, and even the ſcattered pebbles interrupt its courſe, till it unites with other kindred ſtreams, and then ruſhes on the plain below. By its fall it hollows the ground, caſting it up on each ſide: then it purſues its courſe, eating a paſſage through every thing that oppoſes it. When it has received the ſupplies of many rivulets, it is dignified with a name. Thus enlarged, it makes the tour of hills and mountains, and at once adorns and enriches the plains.

At the deluge likewiſe the main iſlands of the globe were formed. But it is certain others have been formed in later ages; partly by the caſting up of vaſt heaps of clay, mud and ſand, (as that of Iſongming in the Chineſe province of Nanquin) partly by the violence of the ſea, tearing off large provinces from the continent. So the ancients imagined Sicily to have been formed, and even Great Britain and Ireland. It is certain alſo, that others have emerged out of the ſea, as Santorini formerly: and three other iſlands near it lately. The laſt of theſe roſe in 1707, from the bottom of the ſea, juſt after a violent earthquake. Indeed earthquakes, ſtorms and inundations, have given riſe to many iſlands: particularly in the Eaſt-Indies, where they are very frequent and which abounds in iſlands above any part of the world.

12. The entire baſon of the ſea, is of ſuch immenſe extent, and covered in many places with ſuch an unfathomable depth of water, that it cannot be traced in every part: but from ſome, we may form a probable judgment of the reſt. The materials which compoſe the bottom of the ſea, muſt in a degree influence the taſte of its waters. Its ſaltneſs it undoubtedly derives from mountains of ſalt which are found there: as bitterneſs from foſſil, coal and other bituminous ſubſtances, which are there in plenty. There may likewiſe be many other ſubſtances, which the plummet does not diſcover. For the true bottom of the ſea is often concealed by another accidental bottom, formed of various ſubſtances, mingled together, and covering it to a conſiderable depth.

The

The entire gulf of Lyons forms a bank above the ſurface of the water at the ſhore, of the exact figure of an arch. And within this there is formed another ſuch arch, making the bottom of the ſea for a great way from ſhore, of different depths in various places, but generally between ſixty and ſeventy fathoms. In general the bed of the main ſea ſinks, about as high as the mountains riſe on the land. Near the land in proportion to the height and ſteepneſs of the ſhores, the ſea is deep below. And on the contrary level ſhores denote ſhallow ſeas.

By the ſtrata on the ſhores we may commonly judge of the bottom of the adjacent ſeas. For the veins of ſalt and bitumen doubtleſs run on in the ſame order as we ſee them at land. And the ſtrata of ſtone that ſerve to ſupport the hills and elevated places on ſhore, ſerve alſo in the ſame continued chain, to ſupport the waters of the ſea. Probably the veins of metals and minerals likewiſe, which are found in the neighbouring earth, are in the ſame manner to be found in the bottom of the ſea.

But the natural ſurface of the bottom of the ſea, is greatly changed by ſubterranean currents. As we ſee theſe break out in rivers, on the ſurface of the earth, ſo we may be aſſured they break out at the bottom of the ſea, and empty their freſh waters into the ſalt maſs. In this caſe the continual ruſhing up of the water, makes a roundiſh cavity. And its running on, continues that cavity, till by degrees it is loſt. Thus every river that ariſes in the bottom of the ſea, when the water near the ſhore is clear, ſhews the traces of theſe currents, even to the naked eye, and the water taken up from them is more or leſs freſh.

Again. The coral fiſheries give us occaſion to obſerve, that there are many large caverns in the bottom of the ſea, eſpecially where it is rocky, as alſo in the ſides of perpendicular rocks. Theſe are often of great depth as well as extent, ſome with wide, others with narrow entrances. Nor is it any wonder, that as we daily find vaſt caverns on the land in rocky mountains, ſo we ſhould find them in rocks under the ſea. Nay, we may expect them in theſe the rather, as the rocks at land are in a ſtate of reſt, while thoſe at ſea

are continually waſhed by the water, which inſinuates every where, and by its continual agitation, enlarges every cavity it finds.

Upon the whole it ſeems plain, that the baſon of the ſea was after the flood compoſed of the ſame ſubſtances as the ſurface of the reſt of the earth, namely, ſtone, clay, ſand, and the like. It is true, the plummet in ſounding uſually brings up a matter compoſed of mud, dead weeds, broken ſhells, and various bodies cemented together by a ſparry or tartareous ſubſtance. But theſe are only an artificial bottom, covering the natural one, ſuch indeed as one might expect, where numerous animals and vegetables are produced and decay, and where the quiet waters have time to depoſit their ſtony matter, as our petrifying ſprings do.

There are places, however, where this adventitious cruſt is not found, but the natural bottom appears of the ſame nature with the ſtrata in the body of the earth. But the fine and pure ſand we ſometimes find, ſeems not to be the original bottom, but to have been rather brought into the ſea by the courſe of ſome ſubterraneous river, and to be lodged in one of thoſe particular baſons, which theſe rivers form to themſelves.

In deep water, where the ſurface only is diſturbed by ſtorms, and the lower part remains quiet for ages, the bottom is covered with a great variety of things: ſometimes with pure ſand, ſometimes a ſort of ſand, made of ſhells beat to powder, ſometimes with powdered corals, ſometimes fragments of rocks. But beſide theſe, which might well be expected, the plummet ſometimes brings up ſubſtances, which are of the moſt beautiful colours: of as fine a ſcarlet, purple, or blue, as the fineſt paint could make them. Thoſe of a bright yellow are very common; but the green or ſnow-white more rare. Theſe coloured ſubſtances ſeem ſometimes to make up the whole bottom. But they are more frequently found on other things, as upon mud, corals, or larger pieces of ſhells, in the manner of tartareous cruſts. And their colours are not merely ſuperficial or tranſient; but many of them are ſo permanent, that they may be preſerved in white wax,

and when thus examined, they appear equal to paints of the fineſt kind.

There is very little difference between the bottom of the Adriatic Sea, and the ſurface of the neighbouring countries. There are at the bottom of the water, mountains, plains, vallies, and caverns, juſt as upon the land. The ſoil conſiſts of different ſtrata planted one upon another; and for the moſt part correſponds to thoſe of the rock, iſlands, and neighbouring continents. They contain ſtones of different ſorts, minerals, metals, various petrified bodies, pumice-ſtones, and lavas formed by volcanos. Iſtria, Dalmatia, Albanſa, and other adjacent countries, as well as the rocks, the iſlands, and the bottom of the Adriatic ſea, conſiſt of a maſs of white marble, of an uniform grain, and of almoſt an equal hardneſs. This vaſt bed of marble in many places under both the earth and the ſea, is interrupted by ſeveral other kinds of marble, and covered by a great variety of bodies. The variety of theſe ſoils under the ſea is remarkable: it is to this are owing the varieties of plants and animals found at the bottom of the ſea. Some places are inhabited by a great number of different ſpecies of plants and animals, in others only ſome particular ſpecies are found, and in others neither plants nor animals. Theſe obſervations not only point out to us the reſemblance between the ſurface of the earth and the bottom of the ſea, but likewiſe one cauſe of the varieties, which are obſerved in the diſtribution of the marine foſſils found in the earth.

In that vaſt maſs of marble, which is common to the bottom of the Adriatic, and the neighbouring provinces towards the eaſt, are a multitude of marine bodies petrified; ſome of which are ſo united to the ſtony ſubſtance, that they are ſcarce to be diſtinguiſhed. Likewiſe a cruſt is diſcovered under the waters in divers places, and for a great extent, which is a compoſition of cruſtaceous and teſtaceous bodies, and beds of polypi of different kinds, confuſedly blended with earth, ſand, and gravel.

Theſe different bodies, which enter into the compoſition of this cruſt, are at the depth of a foot or more,

more, entirely petrified and reduced into marble. At leſs than the depth of a foot they approach nearer to their natural ſtate. And at the ſurface of this cruſt, they are either dead, though extremely well preſerved, or ſtill living.

This demonſtrates that ſtones may be formed from things petrified, and actually are formed in great quantities under the water. Cruſtaceous and teſtaceous bodies and polypi, are every where mingled in the utmoſt confuſion, which ſhews a ſtriking reſemblance between the cruſt diſcovered under the ſea, and the marine bodies petrified in many parts under the earth.

The more theſe cruſtaceous and teſtaceous bodies and beds of polypi multiply, the more their exuvia and ſkeletons contribute to enlarge this cruſt. In ſeveral parts it forms very conſiderable banks, and of a very great thickneſs.

It follows, that the bottom of the ſea is riſing conſtantly higher and higher. Divers other cauſes contribute to this; ſnow and rain, and waters that bring down from the mountains, into the ſea, a great quantity of earth and ſtones. The waves, beating againſt the continent and iſlands, detach many maſſes which are ſpread upon the bottom of the ſea. The rivers carry the mud with their waters into the ſea, at the bottom of which that mud depoſits itſelf.

From the riſing of the bottom of the ſea, that of the level of the water naturally follows. So at Venice, in Iſtria, and in Dalmatia, the level of the waters is ſeveral feet higher than it was formerly. This elevation is obſerved only on the northern and eaſtern coaſts of the Adriatic. The ſea ſeems, on the contrary, to abandon the weſtern coaſt, that of Italy.

The eye can reach but a ſhort way into the depth of any ſea, and that only when the ſurface is glaſſy and ſerene. In many ſeas it perceives nothing but a bright ſandy plain at bottom, extending for ſeveral hundred miles. But in others, particularly in the Red Sea, it is very different: the whole bottom of this extenſive bed of water, is a foreſt of ſubmarine plants, and corals, formed by inſects for their habitation: ſometimes branching out to a great extent;

ſo that ſome have even ſuppoſed the ſea to have taken its name from the colour of its plants below. However, theſe are not peculiar to this ſea, as they are found in great quantities in the Perſian Gulf, along the coaſts of Africa, and thoſe of Provence and Catalonia.

The bottom of many parts of the ſea near America, preſents a very different appearance. This is covered with vegetables, which makes it look as green as a meadow; and beneath are ſeen thouſands of turtles, and other ſea animals feeding therein.

Ocean-ſhells are frequently found very near the ſurface of the earth, which proves that ſuch places formerly have been the ſea-ſhore. Hence it is clear, that the cauſe which tranſported them thither, acted ſuddenly, which perfectly agrees with the account of the deluge given by Moſes.

Nay, at Touraine, in France, more than a hundred miles from the ſea, there is a plain of about nine leagues long, and as many broad, from whence the peaſants of the country ſupply themſelves with marle. If they dig deeper than twenty feet, the whole plain is compoſed of the ſame materials, which are ſhells of various kinds, without the ſmalleſt portion of earth between them. Theſe ſhells are in their natural ſtate; but they are found alſo petrified, and almoſt in equal abundance, in all the Alpine rocks, in the Pyrenees, in the hills of France, England, and Flanders. Yea in all quarters from whence marle is dug, if the rock be ſplit perpendicularly down, petrified ſhells, and other marine ſubſtances will be plainly diſcerned. In ſeveral parts of Aſia and Africa, travellers have obſerved theſe ſhells in great abundance. In the mountains of Caſtravan, they quarry out a white ſtone, every part of which contains petrified fiſhes in great numbers, and of ſurpriſing diverſity, in ſuch preſervation, that their fins, ſcales, and all the minuteſt diſtentions of their make can be perfectly diſcerned. From all theſe inſtances we may conclude, that theſe foſſils are very numerous. And the variety of their kinds is aſtoniſhing. Moſt of the ſea-ſhells which are known, and many others to which we are entirely ſtrangers, are to be ſeen either in their natural ſtate, or in various de-

grees

grees of petrifaction. But in the place of ſome we have mere ſpar, or ſtone exactly expreſſing all the lineaments of animals: for the ſhells diſſolving by ſlow degrees, and the matter having exactly filled all the cavities within, this matter retains the ſame form which the ſhells were of.

The greateſt depths of the ſea ever yet ſounded, have been found to be about 3000 fathoms. The ordinary depths are about 150. Though theſe ſhells are to be found in almoſt all the plainer parts of the ſurface of the earth, yet there are certain very large tracts, where ſuch bodies are never found, viz. the mountains, which ſeem to be the remains of the original ſtrata of the earth. It is true that there are many eminences, which have been taken for mountains, where ſea-ſhells of every kind are found: but theſe are hillocks, compared with the large mountains which may be traced in immenſe chains, without almoſt any diſcontinuity, from one continent to another; and from continents to neighbouring and oppoſite iſlands; inſomuch that all theſe chains, not only of the old, but likewiſe of the new world, ſeem connected one with another. In the Alps, Apennine and Pyreneans, no ſhells, nor marine bodies of any kind are to be found: neither in the large Grampion mountains in Scotland.

The ſame is obſerved of all the large mountains of Africa, and of Aſia, and in the huge chain of Cordilleres in Peru. This kind of mountains (which indeed alone deſerve that name) are chiefly compoſed of vitrifiable matter; and if they are ſometimes found to contain ſea-ſhells, it is never to great depths, though ſuch bodies are found in the adjacent vallies.

Potter's-earth is found plentifully in moſt low grounds and vallies, between mountainous tracts. By expoſing common flint ſtones to the confined vapour of boiling water, a clay of the very ſame kind may be formed, and is no more than a decompoſition of flints. Hence it appears, that wherever this clay is to be found, there the earth has undergone ſome violence by fire; and that this has been effected by earthquakes, ſoon after the deluge, ſeems extremely probable. The de-

luge

luge has given origin to many foſſil ſubſtances and combinations, which otherwiſe would not have happened. Chalk is no more than the ruins of ſea-ſhells, and lime-ſtones conſiſt of the ſame bodies cemented together by a ſtony juice.

13. At fixed times the water of the ſea runs for near ſix hours from ſouth to north, which is called the flood, at which time it riſes gradually on our ſhores, and in the channels of the rivers. Then after ſtanding at the ſame height for a quarter of an hour, it returns for near ſix hours from north to ſouth, which we term the ebb; and after a quarter of an hour the water riſes again. The change thereof is twice in twenty-four hours, but begins near fifty minutes later daily. And this is obſerved on all the ſhores of Europe, that are waſhed by the ocean: whereas the Baltic and Mediterranean ſea, as well as the Caſpian, have no tides. The nearer we approach the pole, the more impetuous the tides are. The cauſe of them was wholly concealed from the ancients; but it is now well known to every one. They depend entirely on the motion of the moon, with which they exactly correſpond: the flood beginning to riſe juſt at the time when the moon is in the meridian.

There is ſomething remarkable in the manner, wherein the tides riſe, in ſeveral of our rivers. In the river Severn, in particular, near Newnham, and 160 miles from Lundy, the head of the flood at ſpring-tides riſes in height like a wall, near nine feet high. Thus it pours on for many miles, uſually overſetting any veſſels that lie in its way. This head-tide they call the boar; it flows here only two, and ebbs ten hours.

But how ſhall we account for the ebbing and flowing of Lay-well, near Torbay? This ebbs and flows many times in an hour. It uſually performs its flux and reflux in a minute's time. But it ſtands two or three minutes after the ebb: ſo that in the whole, it ebbs and flows about ſixteen times in an hour.

14. Currents

14. Currents in the ſea are either natural and general, ariſing from the daily rotation of the earth on its axis, or particular, or accidentally cauſed by the waters being driven againſt promontories, or into gulfs and ſtraits, where wanting room to ſpread, they are driven back, and ſo diſturb the ordinary flux of the ſea.

The currents are ſo violent near the line, where the motion of the earth is the greateſt, that they carry veſſels ſwiftly from Africa to America, but prevent their returning the ſame way. So that they run as far as the fortieth degree, to find a paſſage into Europe.

In the Straits of Gibraltar, which are about twenty miles broad, the current almoſt always runs eaſtward. And ſo it uſually does in St. George's Channel. But the moſt violent ſea is in the Straits of Magellan, which is owing to two contrary currents, which meet in thoſe ſtraits.

Sometimes there is an under-current, contrary to that above. So it is in the Baltic Sound. One of the king's frigates being there, they went with their pinnace in the mid-ſtream, and were carried violently by the current. Soon after they ſunk a baſket with a large cannon-bullet to a certain depth of water. This checked the motion of the boat; and when they ſunk it lower, the boat was driven a head againſt the wind, as well as the upper current. And the lower the baſket was let down, the ſtronger the current was found. The upper current appeared by this experiment, not above four or five fathom deep.

And does not the following inſtance ſhew, that there is an under current at the mouth of the Mediterranean Sea? In the year 1712, Monſ. l'Aigle, commander of a privateer, chaſing a Dutch ſhip near Ceuta Point, came up with her in the Straits between Tariffa and Tangier, and giving her one broadſide, ſunk her. A few days after, this ſhip with her cargo of brandy and oil aroſe near Tangier, four leagues weſt of that place where ſhe ſunk, and directly againſt the ſtrength of the current. Certainly then the deep water in the middle of the Straits, ſets outward to the grand ocean: and poſſibly great part of the water, which runs in at the Straits, may run out again that way.

One

One of the moſt violent currents in the northern ſeas, runs between two of the weſtern iſles. The ſea begins to boil, with the tide of flood, and increaſes gradually, till there are many whirlpools, which form themſelves into a ſort of pyramids, and immediately ſpout out as high as the maſt of a little veſſel. At the ſame time they make a loud report. Theſe white waves run two leagues before they break. The ſea continues theſe motions, till it is more than half flood, and then decreaſes gradually, till it has ebbed half an hour. From that time it boils again, till it is within an hour of low water. This boiling of the ſea is about a piſtol-ſhot diſtant from the iſle of Scarba. But the ſmalleſt boat may ſafely croſs the gulf, at the laſt hour of the flood or of the ebb.

In like manner, the colliſion of the oppoſite and oblique ſtreams, near the end of the Orkney iſlands, excites a circular motion in the water, and when the ſwiftneſs of the tide is conſiderable, occaſions whirlpools or cavities in the ſea, in the form of an inverted bell, wide at the mouth, and growing gradually narrower towards the bottom. Their width and depth are in proportion to the rapidity of the ſtreams that cauſe them. Thoſe in Pentland Firth, near the iſlands Storma and Swona, will, with a ſpring tide, turn any veſſel quite round. There have been inſtances of boats being ſwalled up in them. The cavity is largeſt when it is firſt formed, and is carried along with the ſtream, diminiſhing gradually as it goes, until it quite diſappears. The ſuction communicated to the water, does not extend farther than the cavity. When fiſhermen are aware of their approach to one of theſe wells, as they call them, and have time to throw an oar or any other bulky body into it, before they are too near, the ſpiral motion is interrupted, and the continuity of the water broke; which ruſhing in on all ſides, fills up the cavity, and enables them to go over it ſafe.

The Maelſtroom is a whirlpool on the coaſt of Norway, and received this name from the natives, which ſignifies the navel of the ſea; ſince they ſuppoſe a great ſhare of the water of the ſea is ſucked up, and diſcharged by its vortex. A deſcription of the inter-

nal

nal parts is not to be expected, ſince none ever returned thence to bring information. The body of waters that form this whirlpool, are extended in a circle about thirteen miles in circumference. In the midſt of this ſtands a rock, againſt which the tide in its ebb is daſhed with inconceivable fury. At this time it inſtantly ſwallows up all things that come within the ſphere of its violence, trees, timber, and ſhipping. No ſkill in the mariners, nor ſtrength in rowing, can work an eſcape: the ſailor at the helm finds the ſhip firſt go in a current oppoſite to his intentions: his veſſel's motion, though ſlow in the beginning, becomes every moment more rapid; and it goes round in circles ſtill narrower and narrower, till at laſt it is daſhed againſt the rocks, and inſtantly diſappears: nor is it ſeen again for ſix hours; till the tide turning, it is vomited forth with the ſame violence with which it was drawn in. The noiſe of this vortex increaſes its terror, which, with the daſhing of the waters, and the dreadful valley covered by their circulation, makes one of the moſt tremendous objects in nature.

May I be permitted to mention here, a cheap and eaſy way of making ſea-water freſh: "I took, ſays a gentleman, a long glaſs body, and having filled it with ſea-water, put therein ſea-weed with its roots freſh and new gathered. Then I put on a head and a beak, and adapted a receiver thereto, without any lute or cloſing the joints. From the plants diſtilled daily, a ſmall quantity of very ſweet and potable water. And probably there may be found other plants near the ſea, which would yield freſh water in large quantities."

Sea-water ſimply diſtilled, affords a water as pure and wholeſome, as that obtained from the beſt ſprings.

From the improvements made by Dr. Hales, it appears that three quarts of water might be procured in five minutes, that is, fifty gallons in twelve hours, from a ſmall cylindrical ſtill of Mr. Durand's, by ſetting ſome pewter plates edgeways in its head. And a ſtill thirty-two inches diameter would give two hundred gallons in twelve hours, with only the expenſe of a buſhel and half of coals.

When ſea-water is boiled in a cloſe covered veſſel, the ſteam is converted into freſh water, on the inſide of the cover. And from a pot of thirteen inches diameter, by frequently removing the cover, and pouring off the water collected upon it, a quarter of a pint of freſh water is procured in an hour.

Perhaps a yet better way of making ſea-water freſh, is the following. Take bees-wax, and mould it into the form of an empty hollow veſſel; ſink the veſſel into the ſea. The water in ſome time will work its way through the pores of the wax, and the quantity contained in the veſſel will be freſh, and good for uſe. The ſame will happen by uſing a round earthen veſſel, and ſtopping the aperture: for the water that penetrates is percolated and pure.

But freſh water may be had in much greater plenty, and more expeditiouſly, by filling a veſſel with river-ſand or gravel, and pouring ſalt-water upon it. The veſſel muſt be perforated at bottom, and by applying a linen ſtrainer, the water after undergoing a few filtrations, will loſe all its brackiſh taſte.

In order to keep freſh water ſweet, take of fine, clear, white pearl aſhes, a quarter of a pound of avoirdupoize weight, and put it into one hundred gallons of freſh water (obſerving this proportion to a greater or leſſer quantity) and ſtop up your caſk as uſual, till you have occaſion to broach it for uſe. As an inſtance of its utility and ſucceſs, Dr. Butler put an ounce of pearl aſhes into a twenty-five gallon caſk of Thames water, which he ſtopped up very cloſe, and let it ſtand for upwards of a year and a half, opening it once in four months, and conſtantly found it in the ſame unaltered condition, and perfectly ſweet and good: afterwards he made uſe of ſome of it in boiling peaſe and burgoo, and found that it made the peaſe as ſoft, and anſwered for all purpoſes to which he applied it, as well as water freſh drawn out of the river.

To this ſhort ſketch of what is obſervable in the terraqueous globe, I ſubjoin ſome of the beautiful reflections of Mr. Hervey.

"What

« What an admirable ſpecimen have we here, of the divine ſkill and goodneſs? This globe is intended, not only for a habitation, but for a ſtorehouſe of conveniences. And if we examine the ſeveral apartments of our great abode, we ſhall find reaſon to be charmed with the diſplays both of nice economy and boundleſs profuſion.

The ſurface of it, the ground, coarſe as it may ſeem, is yet the laboratory where the moſt exquiſite operations are performed. And though a multitude of generations have been accommodated by it, it ſtill continues inexhauſtible.

The unevenneſs of the ground, far from being a defect, heightens its beauty and augments its uſefulneſs. Here it is ſcooped into deep and ſheltered vales, almoſt conſtantly covered with verdure, which yields an eaſy couch and agreeable food to the various tribes of cattle. There it extends into a wide, open country, which annually bears a copious harveſt: a harveſt not only of the principal wheat, which is the ſtaff of our life, but of the appointed barley, and various other grain, which are food for our animals.

The furrows vary their produce. They bring forth flax and hemp, which help us to ſome of the moſt neceſſary accommodations of life. Theſe are wove into ample volumes of cloth, which fixed to the maſt, give wings to our ſhips. It is twiſted into vaſt lengths of cordage, which give nerves to the crane, and ſinews to the pully, or elſe adhering to the anchor, ſecure the veſſel even amidſt the driving tempeſt. It covers our tables with a graceful elegance, and ſurrounds our bodies with a cheriſhing warmth.

Yonder ariſe the hills, like a grand amphitheatre! Some are clad with mantling vines, ſome crowned with towering cedars, ſome ragged with miſhapen rocks, or yawning with ſubterraneous caves. And even thoſe inacceſſible crags, thoſe gloomy cavities, are not only a refuge for wild goats, but ſometimes for thoſe of whom the world is not worthy.

At

At a greater diſtance the mountains penetrate the clouds, with their aſpiring brows. Their ſides arreſt and condenſe the vapours as they float along. Their caverned bowels collect the dripping treaſures, and ſend them gradually abroad by trickling ſprings: and hence the waters increaſing roll down, till they have ſwept through the moſt extenſive climes, and regained their native ſeas.

The vine requires a ſtrong reflection of the ſunbeams, and a large proportion of warmth. How commodiouſly do the hills and mountains miniſter to this purpoſe? May we not call thoſe vaſt declivities, the garden-walls of nature? Theſe concentre the ſolar fire, and completely ripen the grape! O that any ſhould turn ſo valuable a gift of God into an inſtrument of ſin!

What is nature but a ſeries of wonders? That ſuch a variety of fruits ſhould riſe from the inſipid, ſordid earth! I take a walk through my garden or orchard in December. There ſtand ſeveral logs of wood on the ground. They have neither ſenſe nor motion; yet in a little time they are beautified with bloſſoms, they are covered with leaves, and at laſt loaded with fruit. I have wondered at the account of thoſe prodigious engines, invented by Archimedes. But what are all the inventions of men, to thoſe nice automata of nature?

The foreſt rears myriads of maſſy bodies, which though neither gay with bloſſoms, nor rich with fruit, ſupply us with timber of various kinds. But who ſhall cultivate them? The toil were endleſs. See therefore the ever wiſe and gracious ordination of Providence! They have no need of the ſpade or the pruning-knife. They want no help from man.

When ſawed into beams they ſuſtain the roofs of our houſes. They make carriages to convey our heaiveſt loads. Their ſubſtance is ſo pliant, that they are eaſily formed into every kind of furniture: yet their texture ſo ſolid, that they compoſe the moſt important

important parts of the largeſt engines. At the ſame time, their preſſure is ſo light, that they float upon the waters. Thus while they ſerve all the ends of architecture, and beſtow numberleſs conveniences on the family, they conſtitute the very baſis of navigation, and give being to commerce.

If we deſcend from the ground floor of our habitation into the ſubterraneous lodgments, we ſhall find there alſo the moſt exquiſite contrivance, acting in concert with the moſt profuſe goodneſs. Here are various minerals of ſovereign efficacy: beds fraught with metals of richeſt value: and mines, which yield a metal of a meaner aſpect, but ſuperior uſefulneſs. Without the aſſiſtance of iron, what would become of all our mechanic ſkill? Without this we could ſcarce either fix the maſt, or drop the faithful anchor. We ſhould ſcarce have any ornament for polite, or utenſil for common life.

Here is an inexhauſtible fund of combuſtible materials. Theſe mollify the moſt ſtubborn bars. They melt even the moſt ſtubborn flint, and make it more ductile than the ſofteſt clay. By this means we are furniſhed with the moſt curious and ſerviceable manufacture in the world; which admits into our houſes the cheering light, yet excludes the wind and rain: which gives new eyes to decrepid age, and more enlarged views to philoſophy; bringing near what is immenſely remote, and making viſible what is immenſely ſmall.

Here are quarries ſtocked with ſtones, which do not ſparkle like gems, but are more eminently uſeful. Theſe form houſes for peace, and fortifications for war. Theſe conſtitute the arches of the bridge, the arms of the mole or quay, which ſcreen our ſhips from the moſt tempeſtuous ſeas. Theſe are comparatively ſoft in the bowels of the earth, but harden when in the open air. Was this remarkable peculiarity reverſed, what difficulties would attend the labours of the maſon? His materials could not be extracted from their bed, nor faſhioned without infinite toil. And were his work completed,

pleted, it could not long withſtand the fury of the elements.

Here are various aſſortments and beds of clay, which however contemptible in its appearance, is abundantly more beneficial than the rocks of diamond or veins of gold: this is moulded into veſſels of any ſhape and ſize: ſome ſo delicately fine as to ſuit the table of a princeſs; others ſo remarkably cheap, that they miniſter to the convenience of the pooreſt peaſant: all ſo perfectly neat, as to give no diſguſt even to the niceſt palate.

A multiplicity of other valuable ſtores is locked up in theſe ample vaults. But the key of all is given to induſtry, in order to produce each as neceſſity demands.

Which ſhall we moſt admire, the bounty or wiſdom of our great Creator? How admirable is his precaution in removing theſe cumbrous wares from the ſurface, and beſtowing them under the ground in proper repoſitories? Were they ſcattered over the ſurface of the ſoil, it would be embarraſſed with the enormous load. Our roads would be blocked up, and ſcarce any room left for the operations of huſbandry. Were they on the other hand, buried at a great depth, it would coſt us immenſe pains to procure them. Were they uniformly ſpread into a pavement for nature, univerſal barrenneſs muſt enſue: whereas at preſent we have a magazine of metallic, without leſſening our vegetable treaſures. Foſſils of every kind enrich the bowels, verdure adorns the face of the earth.

Well then may even the inhabitants of heaven lift up their voice and ſing, "Great and marvellous are thy works, O Lord God Almighty!" And is there not infinite reaſon for us to join this triumphant choir? Since all theſe things are to us, not only a noble ſpectacle, bright with the diſplay of our Creator's wiſdom, but likewiſe an ineſtimable gift, rich with the emanations of his goodneſs! The earth hath he ſet before the inhabitants of his glory: but he hath given it to

the

the children of men. Has he not then an undoubted right to make that tender demand, "My ſon, give me thine heart!"

The rocks which bound the ſea, are here prodigiouſly high and ſtrong, an everlaſting barrier againſt both winds and waves. Not that the omnipotent Engineer has any need of theſe here. It is true, they intervene, and not only repreſs the rolling billows, but ſpeak the amazing Majeſty of the Maker. But in other places the Creator ſhews, he is confined to no expedient. He bids a bank of deſpicable ſand repel the moſt furious ſhocks of aſſaulting ſeas. And though the waves toſs themſelves, they cannot prevail: though they roar, yet they cannot paſs over.

Nay, is it not remarkable, that ſand is a more effectual barrier againſt the ſea than rock? Accordingly the ſea is continually gaining upon a rocky ſhore: but it is continually loſing on a ſandy ſhore, unleſs where it ſets in with an eddie. Thus it has been gaining from age to age, upon the iſle of Portland and the Land's End in Cornwall, undermining, throwing down, and ſwallowing up one huge rock after another. Mean time the ſandy ſhores both on our ſouthern and weſtern coaſts, gain continually upon the ſea.

Beneath the rocks frequently lies a ſmooth, level ſand, almoſt as firm as a well-compacted cauſeway: inſomuch that the tread of a horſe ſcarce impreſſes it, and the waters never penetrate it. Without this wiſe contrivance the ſearching waves would inſinuate into the heart of the earth; and the earth itſelf would in ſome places be hollow as a honey-comb, in other bibulous as a ſponge. But this cloſely-cemented pavement is like claying the bottom of the univerſal canal: ſo that the returning tides only conſolidate its ſubſtance, and prevent the ſun from cleaving it with chinks.

Here the main rolls its ſurges from world to world. What a ſpectacle of magnificence and terror! How it fills the mind and amazes the imagination! It is the moſt auguſt object under the whole heaven. What

are

are all the canals on earth, to this immenſe reſervatory? What are the proudeſt palaces on earth, to yonder concave of the ſkies? What the moſt pompous illuminations, to this ſource of day? They are a ſpark, an atom, a drop. Nay in every ſpark and atom and drop, that proceeds from the hand of the Almighty, there is the manifeſtation of a wiſdom and a power abſolutely incomprehenſible.

Let us examine a ſingle drop of water, only ſo much as will adhere to the point of a needle. In this ſpeck an eminent philoſopher computes no leſs than thirteen thouſand globules. And if ſo many thouſands exiſt in ſo ſmall a ſpeck, how many in the unmeaſured extent of the ocean? Who can count them? As well may we graſp the wind in our fiſt, or mete out the univerſe with our ſpan.

Nor are theſe regions without their proper inhabitants, clothed in exact conformity to the clime: not in ſwelling wool, or buoyant feathers, but with as much compactneſs and as little ſuperfluity as poſſible. They are clad, or rather ſheathed in ſcales, which adhere cloſe, and are laid in a kind of natural oil: than which apparel nothing can be more light, and at the ſame time nothing more ſolid. It hinders the fluid from penetrating their fleſh: it prevents the cold from chilling their blood; and enables them to make their way through the waters, with the utmoſt facility. And they have each an air-bladder, a curious inſtrument, by which they riſe to what height, or ſink to what depth they pleaſe.

It is impoſſible to enumerate the ſcaly herds. Here are animals of monſtrous ſhapes, and amazing qualities. The upper jaw of the ſword-fiſh is lengthened into a ſtrong and ſharp ſword, with which (though not above ſixteen feet long) he ſcruples not to engage the whale himſelf. The ſun-fiſh is one round maſs of fleſh; only it has two fins, which act the part of oars. The polypus, with its numerous feet and claws, ſeems fitted only to crawl. Yet an excreſcence riſing on the back enables it to ſteer a ſteady courſe in the waves.

The

The ſhell of the Nautilus forms a kind of boat, and he unfurls a membrane to the wind for a ſail. He extends alſo two arms, with which as with oars, he rows himſelf along. When he is diſpoſed to dive, he ſtrikes ſail, and at once ſinks to the bottom. When the weather is calm he mounts again, and performs his voyage without either chart or compaſs.

Here are ſhoals upon ſhoals of every ſize and form. Some lodged in their ſhells, ſeemed to have no higher employ, than imbibing nutriment, and are almoſt rooted to the rocks on which they lie: while others ſhoot along the yielding flood, and range the ſpacious regions of the deep. How various is their figure! The ſhells of ſome ſeem to be the rude production of chance, rather than of ſkill or deſign. Yet even in theſe we find the niceſt diſpoſitions. Uncouth as they are, they are exactly ſuited to the exigencies of their reſpective tenants. Some on the other hand are extremely neat. Their ſtructure is all ſymmetry and elegance. No enamel is comparable to their poliſh. Not a room in all the palaces of Europe is ſo adorned as the bedchamber of the little fiſh that dwells in mother of pearl. Where elſe is ſuch a mixture of red, blue and green, ſo delightfully ſtaining the moſt clear and gliſtering ground?

But what I admire more than all their beauty, is the proviſion made for their ſafety. As they have no ſpeed to eſcape, ſo they have no dexterity to elude their foe. So that were they naked, they muſt be an eaſy prey to every free-booter. To prevent this, what is only clothing to other animals, is to them a clothing, a houſe, and a caſtle. They have a fortification which grows with them, and is a part of themſelves. And by means of this they live ſecure amidſt millions of ravenous jaws.

Here dwell mackrel, herring, and various other kinds, which when lean wander up and down the ocean: but when fat they throng our creeks and bays, or haunt the running ſtreams. Who bids theſe creatures leave our ſhores when they become unfit for our ſervice?

ſervice? Who rallies and recals the undiſciplined vagrants, as ſoon as they are improved into deſirable food? Surely the furlow is ſigned, the ſummons iſſued, and the point of re-union ſettled, by a Providence ever indulgent to mankind, ever loading us with benefits.

Theſe approach, while thoſe of enormous ſize and appearance abandon our ſhores. The latter would fright the valuable fiſh from our coaſts; they are therefore kept in the abyſſes of the ocean: juſt as wild beaſts, impelled by the ſame over-ruling power, hide themſelves in the receſſes of the foreſt.

One circumſtance relating to the natives of the deep is very aſtoniſhing. As they are continually obliged to devour one another for neceſſary ſubſiſtence, without extraordinary recruits, the whole watery race muſt ſoon be totally extinct. Were they to bring forth no more at a birth than land animals, the increaſe would be far too ſmall for the conſumption. The weaker ſpecies would ſoon be deſtroyed by the ſtronger, and the ſtronger themſelves muſt ſoon after periſh. Therefore to ſupply millions of animals with their food, and yet not depopulate the watery realms, the iſſue produced by every breeder is almoſt incredible. They ſpawn not by ſcores, but by millions: a ſingle female is pregnant with a nation. Mr. Lewenhoek counted in an ordinary cod 9,384,000 eggs. By this amazing expedient, conſtant reparation is made, proportionable to the immenſe havoc.

And as the ſea abounds with animal inhabitants, ſo it does alſo with vegetable productions: ſome ſoft as wool, others hard as ſtone. Some riſe like a leafleſs ſhrub, ſome are expanded in the form of a net: ſome grow with their heads downward, and ſeem rather hanging on, than ſpringing from the juttings of the rocks. But as we know few particulars concerning theſe, I would only offer one remark in general. The herbs and trees on the dry land are fed by the juices that permeate the ſoil, and fluctuate in the air. For this purpoſe they are furniſhed with leaves to collect the one, and with roots to attract the other. Where-

as

as the ſea-plants, having ſufficient nouriſhment in the circumambient waters, have no need to detach roots into the ground, or forage the earth for ſuſtenance. Inſtead therefore of penetrating, they are but juſt tacked to the bottom, and adhere to ſome ſolid ſubſtance only with ſuch a degree of tenacity, as may ſecure them from being toſt to and fro by the agitation of the waves.

We ſee from this and numberleſs other inſtances, what diverſity there is in the operations of the great Creator. Yet every alteration is an improvement, and each new pattern has a peculiar fitneſs of its own.

Conſidered in another view, the ſea is that grand reſervoir, which ſupplies the earth with its fertility: and the air and ſun are the mighty engines, which work without intermiſſion, to raiſe the water from this inexhauſtible ciſtern. The clouds as aqueducts convey the genial ſtores along the atmoſphere, and diſtribute them in ſeaſonable and regular proportions, through all the regions of the globe.

How hardly do we extract a drop of perfectly ſweet water from the vaſt pit of brine? Yet the ſun draws off every moment millions of tons in vaporous exhalations, which being ſecurely lodged in the bottles of Heaven, are ſent abroad ſweetened and refined, without the leaſt brackiſh tincture, or bituminous ſediment: ſent abroad upon the wings of the wind, to diſtil in dews and rain, to ooze in fountains, to trickle along in rivulets, to roll from the ſides of mountains, to flow in copious ſtreams amidſt burning deſerts and through populous kingdoms, in order to refreſh and fertilize, to beautify and enrich every ſoil in every clime.

How amiable is the goodneſs, how amazing the power, of the world's adorable Maker! How amiable his goodneſs, in diſtributing ſo largely what is ſo extenſively beneficial? That water, without which we can ſcarce perform any buſineſs, or enjoy any comfort, ſhould ſtream by our houſes, ſtart up from the ground; drop down from the clouds. Should come from the ends of the earth, to ſerve us, from the extremities of the ocean! How amazing his power! That this bonndleſs maſs of fluid ſalt, ſo intolerably nauſeous to the taſte, ſhould be the original ſpring, which quenches the thirſt both of man and every animal!

mal! Doubtleſs the power by which this is effected, can make "all things work together for our good."

Vaſt and various are the advantages which we receive from this liquid element. The waters glide on in ſpacious currents, which not only cheer the adjacent country, but by giving a briſk motion to the air, prevent the ſtagnation of the vapours. They paſs by large cities, and quietly rid them of a thouſand nuiſances. But they are alſo fit for more honourable ſervices. They enter the gardens of a prince, float in the canal, aſcend in the Jet d'Eau, or fall in the grand caſcade. In another kind they ply at our mills, toil inceſſantly at the wheel, and by working the largeſt engines, take upon them an unknown ſhare of our fatigue, and ſave us both labour, time, and expenſe.

So forcibly do they act when collected. And how do they inſinuate when detached? They penetrate the minuteſt tubes of a plant, and find a paſſage through all its meanders. With how much difficulty does the labourer puſh his way up the rounds of a ladder? While theſe carry their load to a much greater height, and climb with the utmoſt eaſe. They convey nouriſhment from the loweſt fibres that are plunged in the earth, to the topmoſt twigs that wave amidſt the clouds. Thus they furniſh the whole vegetable world with neceſſary proviſion, by means of which "the trees of the Lord are full of ſap, even the cedars of Lebanon, which he hath planted." And notwithſtanding their vaſt elevation and prodigious diffuſion, not a ſingle branch is deſtitute of leaves, nor a ſingle leaf of moiſture.

Beſides the ſalutary and uſeful circulation of the rivers, the ſea has a motion no leſs advantageous. Daily for five or ſix hours, it flows toward the land, and for the ſame time, retires to its inmoſt caverns. How great is the power that protrudes to the ſhores ſuch an inconceivable weight of waters, without any concurrence from the winds, often in direct oppoſition to them! Which bids the mighty element revolve with the moſt exact punctuality! Did it advance with a lawleſs and unlimited ſwell, it might deluge whole continents. Was it irregular and uncertain in its approaches, navigation would be at a ſtand. But being conſtant in its

ſtated

ſtated period, and never exceeding its appointed bounds, it does no prejudice to the country, and ſerves all the ends of traffic.

Is the ſailor returned from his voyage? The flux is ready to convey his veſſel to the very doors of the owner, without any hazard of ſtriking on the rocks, or of being faſtened in the ſands. Has the merchant freighted his ſhip? The reflux bears it away with the utmoſt expedition and ſafety. Behold, O man, how highly thou art favoured by thy Maker! "He hath put all things in ſubjection under thy feet. All ſheep and oxen, all the beaſts of the field: the fowls of the air, and the fiſhes of the ſea." Yea, the ſurges of the ſea are ſubſervient to thee. Even theſe, wild and impetuous as they are, are ready to receive thy load, and like an indefatigable beaſt of burden, carry it to the place which thou chuſeſt.

What preſerves this vaſt flood in perpetual purity? It receives the refuſe and filth of the whole world. Whatever would defile the land and pollute the air, is tranſmitted to the ocean. How then is this receptacle of every nuiſance kept clean, kept from contracting a noiſome and peſtilential taint? It is partly by its inceſſant motion, and partly by its ſaltneſs. By the one it is ſecured from any internal principle of corruption; by the other it works itſelf clear of any adventitious defilement.

Conſider the ſea in another capacity, and it connects the remoteſt realms of the univerſe, by facilitating the intercourſe, between their reſpective inhabitants. The ancients indeed looked on the ocean, as an impaſſable gulf. But we find it juſt the reverſe; not a bar of ſeparation, but the great bond of union. For this purpoſe it is never exhauſted, though it ſupplies the whole earth with rain: nor overflows, though all the rivers in the univerſe are perpetually augmenting its ſtores. By means of this we travel farther, than birds of the ſtrongeſt pinions fly. We croſs the flaming line, viſit the frozen pole, and wing our way even round the globe.

What a multitude of ſhips are continually paſſing and repaſſing this univerſal thorough-fare! Whole harveſts of corn and vintages of wine, lodged in vola-

tile

tile ſtore-houſes, are wafted by the breath of heaven, to the very ends of the earth: wafted, enormous and unwieldly as they are, almoſt as ſpeedily as the roe bounds over the hills.

Aſtoniſhing, that an element ſo unſtable, ſhould bear ſo immenſe a weight! That the thin air ſhould drive on with ſuch ſpeed thoſe vaſt bodies, which the ſtrength of a legion could ſcarce move! That the air and water ſhould carry to the diſtance of many thouſand miles, what the united force of men and machines could ſcarce drag a ſingle yard! "Great and marvellous are thy works, O Lord God Almighty!"

How are the mariners conducted through this fluid common, than which nothing is more wide or more wild? Here is no tract, no poſts of direction, nor any hut where the traveller may aſk his way. Are they guided by a pillar of fire? No, but by a mean, and otherwiſe worthleſs foſſil. Till this ſurpriſing ſtone was diſcovered, ſhips crept timorouſly along the coaſts. But this guides them, when nothing but ſkies are ſeen above, and nothing but ſeas below. This gives intelligence that ſhines clear in the thickeſt darkneſs, and remains ſteady in the moſt tempeſtuous agitations. This emboldens us to launch into the heart of the ocean, and to range from pole to pole.

By this means are imported to our iſlands the choice productions of every nation under heaven. Every tide conveys into our ports, the treaſures of the remoteſt climes. And almoſt every private houſe in the kingdom, is accommodated from the four quarters of the globe. At the ſame time that the ſea adorns the abodes of the rich, it employs the hands of the poor. What a multitude of people acquire a livelihood, by preparing commodities for exportation? And what a multitude by manufacturing the wares imported from abroad? Thus though it is a falſe ſuppoſition, that the waters themſelves are ſtrained through ſubterranean paſſages into the inland countries, yet it is true, that their effects are transfuſed into every town, every hamlet and every cottage."

I beg leave to inſert here what could not properly come in under any of the preceding articles.

It

It is a curious remark, which Dr. Cheyne makes concerning fluids in general. "I take notice, firſt of the fewneſs of the original fluids, in reſpect of the vaſt number of compound ones. The primary ones hitherto known are only four, air, water, mercury, and light, three of which are ſeldom much compounded with others; ſo that it is water alone, that is the baſis of all our mixtures. It is the parts of ſolid bodies floating in this fluid, that produce all our delightful and uſeful varieties of liquors: ſo frugal is nature in principals, and ſo fruitful in effects and compoſitions. Take notice, 2dly, Of the great difference between the ſpecific gravities of our fluids, mercury being eight thouſand times heavier than air. Now not to mention the many uſes of this laſt fluid in artificers works, had air been as heavy as mercury it had been altogether uſeleſs in reſpiration: it had choked us immediately. And had there not been a fluid of the ſame weight with mercury, i. e. a collection of exceeding ſmall, heavy ſpherules, in the preſent circumſtances of mankind, I do not know what a great part of the world would have done. For the wickedneſs of mankind, has brought many diſeaſes to that degree of malignity, that a thorough cure could ſcarce be made of them without this fluid. But by the gravity of this, a remedy is provided for all theſe maladies, which are more than two or three. But that which is moſt wonderful in theſe fluids is, 3dly, That univerſal property, the direction of their preſſure upon the ſides of the containing veſſel. In all fluids of whatſoever kind or nature this preſſure is communicated in lines perpendicular to the ſides of the containing veſſel. And indeed this property of fluids, which is ſo uniform, is the neceſſary conſequence of the ſphericity of their conſtituent particles.

Now, could any thing but the almighty power of God, have rounded thoſe infinite numbers of ſmall particles? Or could any thing but his wiſdom have aſſigned them their true dimenſions, their exact weights, and required ſolidities? We ſhall allow him to continue in his infidelity, who can demonſtrate by what laws of mechaniſm, all the particles of water were turned of the ſame diameters, ſolidity, and weight; and thoſe of air, mercury, and light turned all of different

ferent diameters, ſolidities, and weights from one another; but all of the ſame diameters, ſolidities, and weights among themſelves. And what a beautiful idea of this fluid do Sir Iſaac Newton's later diſcoveries preſent us with? Every ray is endowed with its own colour, and its different degree of refrangibility and reflexibility. One ray is violet, another indigo, a third blue, a fourth green, a fifth yellow, a ſixth orange, and the laſt red. And theſe are the primary and original colours, from the mixture whereof all the intermediate ones proceed; and white from an equal mixture of the whole; black on the contrary, from the ſmall quantity of any of them being reflected; or all of them in a great meaſure ſuffocated. So that it is not properly bodies that are coloured, but the light that falls upon them; and their colours ariſe from their aptitude, to reflect rays of one colour, and tranſmit all thoſe of another. The prominent little parts, upon their ſurface, according to their different degree of denſity and thinneſs, are apt to reflect back upon our organ, rays of one colour, and of one degree of refrangibility and reflexibility, and to let others paſs through their pores. And this one colour too is leſs or more intenſe, according as their prominent parts are of different denſities. For the firſt degrees of intenſeneſs, in all the primary colours, ſeem to ariſe from the degrees of denſity and thinneſs; and the ſubſequent degrees, from the other different degrees of thickneſs, or thinneſs of the prominent little parts of the ſurfaces of bodies. Light acts upon bodies by heating, diſſolving, and putting their parts into a vibrating motion. Bodies act upon light, in drawing its parts to them, and that in lines perpendicular to their ſurfaces. And as there may be different degrees of attraction in bodies, which produce their different degrees of elaſticity and coheſion, ſo there muſt be different degrees of attraction in mediums ſuppoſed, to account for their different powers, in bringing the refracted rays nearer to, or farther from the perpendicular. For it is well known all mediums have not the ſame refractive virtue. Now what a beautiful, uniform, and ſimple theory of light is here! This is ſo very like the frugal ſimplicity, and yet the manifold variety of nature, that one would

would be almoſt tempted to believe it true, were there no experiment to confirm it. We may obſerve one more inſtance of the wonderful wiſdom of nature, in the propagation of light, viz. That a ray of light in paſſing from a luminous point, through two differently refracting mediums, to illuminate a given point, ſpends the leaſt time (the refracting powers of the ſeveral mediums conſidered) poſſible; and conſequently when a ray paſſes through one medium, from a luminous point to reflect upon a given point, it takes the ſhorteſt way poſſible. This the geometers have demonſtrated. Now is not this an inſtance of counſel and deſign? Is not this like the methods of wiſdom, which will not ſpend more time on a thing than juſt what is neceſſary to do the buſineſs; which will not go about, but take the ſhorteſt courſe poſſible that will bring it to the place deſigned?"

The iſlands of Scilly have been ſo noted among the ancients, one might expect to find among the inhabitants ſome conſciouſneſs of their own antiquity, and of their appearance in hiſtory before the other parts of Britain were at all known. But there is nothing of this kind; the inhabitants are all new comers, not an old habitation worth notice, nor any remains of Phœnician, Grecian, or Roman arts, either in town, caſtle, port, temple, or ſculpture.

We are not to think however, but Scilly was inhabited, and was frequently reſorted to anciently, as the old hiſtorians relate. All the iſlands (ſeveral of which are now without inhabitants) by the remains of walls, foundations of many contiguous houſes, and a great number of ſepulchral burrows, ſhew, that they have been fully cultivated and inhabited.

That they were inhabited by Britons, is paſt all doubt, not only from their neighbourhood to England, but from the Druid monuments. Several rude ſtone pillars, circles of ſtone erect, rock-baſons: all monuments common in Cornwall and Wales, are equal evidences of the antiquity, religion, and original of the old inhabitants.

How came theſe ancient inhabitants then (it may be aſked) to vaniſh, ſo as that the preſent have no preten-

ſions of any affinity of any kind with them, either in blood, language, or cuſtoms? How came they to diſappear, and leave ſo few traces of plenty, or arts, and no poſterity behind them? From two cauſes; the manifeſt encroachments of the ſea, and as manifeſt a ſubſidence of ſome parts of the land.

The ſea is the inſatiable monſter which devours iſlands, gorges itſelf with the earth, ſand, clay, and all the yielding parts, and leaves nothing where it can reach, but the ſkeleton, the bared rock. The continual advances, which the ſea makes upon the low lands, are plain to all people of obſervation. What we ſee happening every day may aſſure us of what has happened in former times; and from the banks of ſand and earth giving way to the ſea, and the breaches becoming ſtill more open, and irrecoverable; it appears, that repeated tempeſts have occaſioned a gradual diſſolution of the ſolids for many ages.

Again, the flats which ſtretch from one iſland to the other, are plain evidences of a former union between many now diſtinct iſlands. The flats between ſome of them are quite dry at a ſpring-tide, and men eaſily paſs dry ſhod from one iſland to the other, over ſand-banks where, upon the ſhifting the ſands, walls and ruins are diſcovered frequently, upon which at full ſea there are ten and twelve feet of water. All ſtrong arguments that theſe iſlands were once one continued tract of land, though now as to their low lands overrun with the ſea and ſand. Hiſtory confirms their former union "The iſles Caſſiterides (ſays Strabo) are ten in number, cloſe to one another; one of them is deſert and unpeopled, the reſt are inhabited." But ſee how the ſea has multiplied theſe iſlands! There are now reckoned one hundred and forty. Into ſo many fragments are they divided, and yet there are left ſix inhabited. But no circumſtance can ſhew the great alterations, which have happened in the number and extent of theſe iſlands, more than this, viz. that the iſle of Scilly, from which the little cluſter takes its name, is no more at preſent than a high rock, of about a furlong over, whoſe cliffs hardly any thing but birds can mount, and whoſe barrenneſs could never ſuffer any thing but ſea-birds to inhabit it. How then came

all

all theſe iſlands to have their general name from ſuch a ſmall and uſeleſs plot?

Doubtleſs Scilly, which is now a bare rock, and ſeparate from the lands of Guel and Brehar by a narrow frith, was formerly joined to them by low necks of land, being the rocky promontory of one large iſland now broke into ſeven. This promontory (at preſent called Scilly-iſland) lying weſtermoſt of all the high lands, was the firſt land of all the iſlands diſcerned by the traders from the Mediterranean and Spaniſh coaſts, and, as ſoon as diſcovered was ſaid to be Scilly, nothing being more uſual with ſailors, upon their firſt ſeeing land, than to call the part by the whole. But when this conſiderable iſland called Scilly was broken to pieces, the greateſt portions became inhabited, and had firſt Britiſh names, as Brehar, Treſcaw, Enmor; but afterwards were called according to the religion of the times, after the names of particular ſaints. The chief diviſion was intitled St. Mary's, the others dedicated to St. Nicholas, St. Martin, St. Theon, and ſo on; but this remarkable promontory being in no wiſe fit for habitation or devotion, was dedicated to no ſaint, but left to enjoy its ancient name; and notwithſtading the modern Chriſtian dedications, ſailors went on in their old way. This high land is ſtill called Scilly, and the iſlands in general are ſtill denominated Scilly-iſles.

It muſt have been a diſpiriting circumſtance to the old inhabitants, to ſee the ocean ſo continually eating away their low-lands, in which they had their treaſures of tin, their houſes and ports: but this gradual decay was not the only misfortune which attended them. From the iſland of Sampſon, one may ſee the foundations of ſtone fences running on in a ſtrait line croſs the frith, towards Treſcaw-iſle, till they are hid in the ſand; which ſand, when it is full tide, has from ten to twelve feet water on it. Now we cannot ſuppoſe that the foundation of theſe fences was laid as low as high water mark, (for who could build fences upon ſo dangerous a level?) At a medium we may ſuppoſe them to have been laid ſix feet above the full tide.

Here then we have the foundations, which were ſix feet above the high-water mark, now ten feet under, which together make a difference as to the level of ſixteen feet.

Here then was a great ſubſidence, which muſt have been followed by a ſudden inundation, and this inundation, is likely not only to have deſtroyed a great part of the inhabitants, but to have terrified others who ſurvived into a total deſertion of their ſhattered iſlands. By this means that conſiderable people, who were the Aborigines, and carried on the tin-trade with the Phœnicians, Greeks, and Romans, were reduced to the laſt gaſp. The few poor remains of this deſolation, by their neceſſary attention to food and raiment, muſt ſoon have loſt ſight of their ancient proſperity, and the faint remembrance that was left of what the iſlands had been before, expired of itſelf in an age or two, through the indigence of the inhabitants.

That ſuch an inundation has happened here, is ſtill more plain, becauſe theſe iſlands are no longer what they were anciently, fertile in tin: nor are there any remains of ſo many ancient workings as could maintain a trade ſo greedily coveted by the ancients. But what is become of thoſe mines? How ſhall this queſtion be anſwered, but by confeſſing that the land, in which they were, is now ſunk, and buried under the ſea?

I am not fond of introducing earthquakes; but where there has been evidently a great ſubſidence of the earth's ſurface, can it be accounted for at all without a previous concuſſion of the earth? And what nature declares in this caſe, tradition ſeems to confirm; there being a ſtrong perſuaſion in the weſtern parts of Cornwall, that formerly there exiſted a large country between the Land's End and Scilly, now laid many fathoms under water. Indeed there are no evidences of any ancient connexion of the Land's End and Scilly. Yet that the cauſe of that inundation, which deſtroyed much of theſe iſlands, might reach alſo to the Corniſh ſhores, is extremely probable; there being ſeveral evidences of a like ſubſidence of the land in Mount's-Bay. The principal anchoring-place, called a lake, is now a haven or open harbour. The mount

from

from its Corniſh name, we muſt conclude to have ſtood formerly in a wood; but now at full tide, it is half a mile in the ſea, and not a tree near it; and in the ſandy beach betwixt the Mount and Penzance, when the ſands have been diſperſed by violent high tides, there have been ſeen the trunks of ſeveral large trees in their natural poſition, the ſurface of their ſection worn ſmooth by the agitation of the water, ſand, and gravel, as if cut with an axe, upon which at every full tide, there muſt be twelve feet water; ſo that the ſhores in Scilly, and the neighbouring ſhores of Cornwall are concurrent evidences of ſuch a ſubſidence, and the memory of the inundations, which were the neceſſary conſequences of it, is preſerved in tradition: though like other traditions, in proportion to their age, obſcured by fable.

That there has been ſuch a ſubſidence of the lands, belonging to theſe iſlands, the preſent ruins of the iſlands teſtify. And this ſubſidence reached even to Mount's-Bay, and laid under water a great part of the low-lands then woody, there being now ten feet water, ſo, that the ſhores in Scilly and the ſhores in Cornwall, are equal proofs of ſuch an inundation. When this inundation happened, we know not; but two pieces of hiſtory poſſibly may lead us near the time. In the time of Strabo and Diodorus Siculus, their commerce was in full vigour. "Abundance of tin was carried in carts," ſays Diodorus Siculus. "But ten iſlands in all (ſays Strabo) and nine of thoſe inhabited." The deſtruction therefore of Scilly muſt be placed after the time of theſe authors; that is, after the Auguſtan age.

Now Plutarch hints, that the iſlands round Britain were generally unpeopled in his time. If he includes Scilly among them, then this deſolation muſt have happened between the reign of Trajan, and that of Auguſtus.

15. At the mouth of the river Neſs, near Burgeſpu, in Flanders, at the depth of fifty feet, are found great quantities of trees lying as cloſe to each other, as they do in a wood; the trunks, the branches, and the leaves, are in ſuch perfect preſervation, that the particular

cular kind of each tree may be known. About five hundred years ago this very ground was known to have been covered with the ſea; nor is there any hiſtory of its having been dry ground, which no doubt muſt have been the caſe. Thus we ſee a country flouriſhing in verdure, producing large foreſts, and trees of various kinds, overwhelmed by the ſea. We ſee this element depoſiting its ſediment to a height of fifty feet; and its waters muſt, therefore have riſen much higher. We ſee the ſame after it has thus overwhelmed, and ſunk the land ſo deep beneath its ſlime, capriciouſly retiring from the ſame coaſts, and leaving it habitable once more. All this is wonderful, and perhaps inſtead of attempting to inquire after the cauſe, it will beſt become us to reſt ſatisfied with admiration.

At the city of Modena in Italy, about four miles round it, whenever they dig, when the workmen arrive at the depth of ſixty-three feet, they come to a bed of chalk, which they bore with an augre five feet deep. They then withdraw from the pit, before the augre is removed, and upon its extraction, the waters burſt up through the aperture with great violence. That which is moſt remarkable in the operation is the layers of earth, as we deſcend. At the depth of fourteen feet are found the ruins of an ancient city, paved ſtreets, houſes, floors, and different pieces of Moſaic. Under this is found a ſolid earth, that one would imagine had never been removed; however, under it is found a ſoft oozy earth, made up of vegetables; and at twenty-ſix feet deep, large trees entire, ſuch as walnut-trees, with the walnuts ſtill ſticking on the ſtem, and their leaves and branches in exact preſervation. At twenty-eight feet deep a ſoft chalk is found mixed with a vaſt quantity of ſhells, and this bed is eleven feet thick. Under this vegetables are found again with leaves and branches of trees as before; and thus alternately chalk and vegetable earth, to the depth of ſixty-three feet. Theſe are the layers whenever the workmen bore; while in many of them they alſo find pieces of charcoal, bones, and bits of iron. From this deſcription it appears, that this country has been alternately overflowed and deſerted by the ſea, one age after another: nor were theſe overflowings and retirings

of

of triffing depths, or of ſhort continuance. When the ſea burſt in, it muſt have been a long time in overflowing the branches of the fallen foreſt with its ſediment; and ſtill longer in forming a regular bed of ſhells, eleven feet thick over them. It muſt have therefore taken an age, at leaſt to make any one of theſe layers; and we may conclude, that it muſt have been many ages employed in the production of them all. The land alſo, upon being deſerted, muſt have had time to grow compact, and to be drained of its waters before it could be diſpoſed to vegetation.

Likewiſe in cutting a channel for the canal of Newry, in Ireland, a great multitude of fallen trees was diſcovered, lying near two miles in length, and in many places, ſix or eight feet deep. Many of theſe are very large, and are tumbled down one over another, ſome lying in ſtrait lines, and others in an oblique or tranſverſe poſition. If trees thus found had been felled by the deluge, (as undoubtedly others were) they would all lie in one poſition. But this is not the caſe. We muſt therefore ſeek for other cauſes. And one cauſe ſeems to have been this. If water flowing either from ſprings or ſtreams be ſtopt, it naturaly ſoftens and looſens the earth; and in courſe of time, even to the roots of trees, which are then ſubject to be overturned by any violent ſtorm. This doubtleſs was the caſe with moſt of thoſe trees, that are found in bogs with the roots adhering to them. Trees thus falling ſink into the yielding ſoil, and cauſe a farther ſtoppage in the courſe of the waters. Hence the looſe earth is increaſed, by a yearly acceſſion of ſcurf, moſs, graſs, and weeds. Add to this, that the higher lands being gradually diſſolved by repeated rains, and waſhed down by floods, in a long courſe of years, cover the lower grounds with freſh layers of earth. This being ſo, it is not ſtrange to find trees buried eight or ten feet under the earth.

Another cauſe may be this. Various colonies from time to time arriving in the then uncultivated country of Ireland, would naturally make room for tillage and paſture, by clearing the ground of its foreſts. This was certainly the caſe, where we find in bogs, trees partly

partly burned, and others bearing the mark of the axe. But ſometimes theſe colonies were driven by the natives from their intended ſettlements, leaving the trees they had felled, ſtrewed over the plain, which ſtopping the waters, of courſe created bogs, that in proceſs of time covered thoſe trees to a conſiderable depth. Nay, as late as 1561, Tyrone and O'Donnel marching toward Kinſale through Connaught, and laying the country waſte, there is a great tract of ground, now a bog, which was then ploughed land.

That bogs in general grow but ſlowly may be gathered from a lump of coins of Edward IV. (probably loſt in a purſe which rotted away) taken up in a bog in Yorkſhire, eighteen feet deep. This was about 300 years before. So the bog had grown about a foot in eleven years, that is, ſomewhat above an inch in a year: although ſome ſeem to grow much faſter.

Much more ancient is the great level, or fenny ground, which contains about 300,000 acres, lying in the counties of Norfolk, Suffolk, Cambridge, the Iſle of Ely, Huntingdon, Northampton, and Lincoln. This was once firm land. There have been found therein ſtones, bricks, and other materials for building. In ſetting down a ſluice, there was found ſixteen feet deep, a ſmith's forge, and all the tools thereunto belonging. William of Malmſbury, who lived 1200 years ago, ſays that in his time, "The trees which grew there, ſmooth and ſtrait, were ſo tall that they ſeemed to touch the ſtars. A plain there is, as even as the ſea, which with the green graſs, allures the eye; and there is not the leaſt parcel of ground that lies waſte and void. Here you ſee plantations of fruit-trees; there a field ſet with vines, part creeping on the ground, part mounting on high poles." But how came it to be reduced to ſo very different a ſtate? It ſeems the ocean broke in upon it, with ſuch reſiſtleſs violence, that the buildings throughout the whole ſpace was overturned, and the trees torn up by the roots. The amazing quantity of ſilt thrown up at the ſame time, covered the whole country, even to the verge of the Highlands, ſeven, eight, or even ten feet deep. Hence a few years ſince, in digging a pool, there was found at the upper ſkirts of the level, the

ſkeleton

ſkeleton of a large fiſh, near twenty feet long, lodged in ſilt above ſix feet below the ſurface of the ground. Yet how or when this inundation was, we are not able to determine. Whenever it was, it was probably occaſioned by a violent earthquake.

A late writer gives the following account of the natural origin of bogs in Ireland. Some of theſe have vaſt quantities of timber under them: others have very little. But the ſurface of all is covered with a ſhort, thick, and matted kind of heath. This as it grows, and thickens at the top, vegetates at the bottom into a cloſe texture, which being replete with moiſture, throws out annual growths of this ramified heath, part of which dies every winter, and moulders at the bottom, where it forms another ſtratum, from which at ſpring comes a new crop of heath. And thus as theſe ſtrata of mouldered heath are annually repeated, the roots increaſe, and at once extend higher, and are more conſolidated at the bottom. Hence the turf is ever found of a cloſer texture, as we deſcend deeper in the bog.

The turf is itſelf only a cloſely concreted combination of the roots of this heath, which univerſally grows on the ſurface of theſe bogs; not the produce of the trees which are at the bottom. Wherever theſe were thrown down, ſome earth would be waſhed down upon them from the adjacent grounds, the ſurface of which every where produces this heath. And this being now ſupplied with conſtant moiſture, would throw out a more plentiful growth.

The ſame cauſe produces theſe bogs on the ſides or even tops of mountains. But it is ever in wet grounds, or in flats on the ſide of hills where the water ſettles, and ſupplies them with moiſture.

There ſeems indeed to be a ſpungy quality in this heath, which prevents the moiſtures ſinking away from it, by an attraction of the fluids, by an infinite number of capillary fibres, which are the very ſubſtance of it. At the bottom of theſe mountain-bogs, no trees are found. And very few in the largeſt bogs, unleſs on the ſkirts of them.

The turf then from top to bottom is entirely the

produce of a vegetation from itſelf. And the reaſon why Ireland produces ſo many turf-bogs, is becauſe it ſo abounds with the ſeeds of this heath, which is every where found where the land is uncultivated, and forms bogs wherever it has proper moiſture.

Our marle is found only in the bottom of low bogs, at the depth of ſeven, eight, or nine feet. For three feet is a ſpungy ſort of earth, then gravel for about half a foot. For about three feet more is a ſpungy earth, mixed with timber, but ſo rotten, that it cuts like earth. Next this for the depth of three inches we find leaves, that are fair to the eye, but will not bear a touch. With theſe are ſometimes mixed heaps of ſeed, which ſeem to be broom or furze ſeed: nay, in one place, what ſeemed to be gooſeberries and currants, was found, and ſea-weed in others. Under this was blue clay half a foot thick, thoroughly mixed with ſhells, as was alſo the marle, which lay next, three or four feet deep. They are ſhells of periwinkles; and among theſe are large horns and bones anſwerable thereto. But it is not only in bogs that ſubterraneous trees are found; nor in Ireland only, but in many parts of England. At Youle, about twelve miles from York, near the place where the Dun empties itſelf into the Humber, abundance of them have been dug up from time to time; all of which are a ſpecies of fir. In the iſle of Axholme in Lincolnſhire, not firs only, but abundance of oaks are found in the moor, whereof ſome are five yards in compaſs, with quantities of acorns near them. The firs lie ſomewhat deeper than the oaks; one of them was thirty-ſix yards long. The adjoining levels (about 18000 acres) were half of them yearly covered with water, till King Charles I. ſold them to Sir Cornelius Vermuyden, who drained them at the charge of above 400,000l. In the ſoil of all this land, through all Marſhland, and on the ſkirts of all the Lincolnſhire and Yorkſhire wolds, are found millions of roots and bodies of trees, firs, oaks, birch, beech, yew, willow, and aſh. The roots ſtand in their natural poſtures, as thick as ever they could grow. The bodies of moſt of the great trees, lie all their length about a yard from their roots, with their tops north-eaſt. The ſmaller

lie

lie acroſs in every direction, ſome under, ſome above them. Some of the oaks are thirty, ſome thirty-five yards long, yet wanting ſome yards at the ſmall ends. They are firm, laſting, and as black as ebony. Many of them have been burnt, ſome quite through, ſome on one ſide. Some have been found chopped and ſquared, ſome bored through; ſome half cleft, with great wooden wedges in them, and broken axe heads, ſhaped not unlike the ſacrificing axes. And all theſe were in ſuch places, and at ſuch depths, as could not have been opened, from the time the foreſt was deſtroyed until the ground was drained. Near a great root in the pariſh of Hatfield, were found eight or nine Roman coins: and at the bottom of a new drain, were found trees ſquared and cut, rails, bars, a kind of battle-axe, and two or three coins of the Emperor Veſpaſian. Nay, the ground at the bottom of the river was found to lie in ridge and furrow, manifeſting that it had been ploughed. In an old drain, an oak was found forty yards long, four yards in diameteer at the great end, three yards and a foot in the middle, two yards at the ſmall end; ſo that by a moderate computation, it ſeems to have been as long again. Yea, about fifty years ago, there was found ſeveral feet deep, a man lying at his full length, with his head upon his arm as aſleep. His ſkin, tanned, as it were, by the moor-water, preſerved his ſhape entire; but his fleſh and moſt of his bones were conſumed.

Theſe ſtately trees formerly compoſed one of the moſt beautiful foreſts in the world. But how came it to be deſtroyed? When the Romans purſued the Britons, they always fled into the woods. On this the Roman generals ordered them to be cut down; this vaſt foreſt in particular. The trees falling croſs the rivers which ran through the country, ſoon dammed them up, turned the ground into a lake, and gave riſe to the moors, that increaſed continually, by earthy matter waſhed down, the conſumption of rotting branches and leaves, and the growth of water-moſs, which wonderfully flouriſhes on rotten grounds. Hence it , that ſo many Roman coins have been found at the bottom of theſe levels; that ſo many trees are found burnt or chopped; and that the ſoil of

the

the country in general is two, three or more yards higher than formerly.

Some ſimilar alteration ſeems to have happened many centuries ago, to that whole tract of land, near Newbury in Oxfordſhire, out of which they dig their peat. There is a ſtratum of this ſeveral miles which lies many feet under the ſurface.

The beſt peat has very little (if any) earth in it, but is a compoſition of wood, branches, twigs, leaves, and roots of trees, with graſs, ſtraw, plants, and weeds. The colour is of a blackiſh brown: and if it be chewed between the teeth it is ſoft, and has no gritty matter in it. It is indeed of a different conſiſtence in different places, ſome being ſofter and ſome harder: which may ariſe perhaps from the different ſorts of trees it is compoſed of. Great numbers of trees are viſible in the true peat, lying irregularly one upon another, and ſometimes even cart-loads of them have been taken out: but the nearer theſe trees lie to the ſurface, the leſs ſound is the wood; and ſometimes the ſmall twigs which lie at the bottom, are ſo firm as not to be eaſily cut through: theſe trees are generally oaks, alders, willows, and firs, beſides ſome others not eaſily known. The ſmall roots are generally periſhed, but yet have ſufficient ſigns to ſhew that the trees were torn up by the roots, and were not cut down; there being no ſign of the axe or ſaw, which, had they been felled, would have been plainly viſible. A great many horns, heads, and bones of ſeveral kinds of deer, horns of the antelope, heads and tuſks of boars, and heads of beavers, are alſo found in it, and ſome human bones.

Before we diſmiſs this ſubject, it may not be improper to ſubjoin as ſtrange an account as any age can parallel. June 7, 1697, near Charleville in Ireland, a great rumbling was heard in the earth. Soon after, in the bog of Kapanihane, ſtretching north and ſouth, ſome meadow and paſture land, that lay on the ſide of the bog, ſeparated by a large ditch, and other land on the further ſide adjoining to it, began

to

to move: and a little hill in the middle of the bog ſunk down.

This was at ſeven in the evening, the ground fluctuating in its motion, like the waves of the ſea. The paſture-land then roſe up, over-ran the ground beneath, and moved upon its ſurface: rolling on with great violence, till it had covered the meadow ſixteen feet deep. It drew after it the body of the bog, part of it lying on the place where the paſture-land was before, leaving great breaches behind it, and currents of water, which caſt up noiſome vapours. There are ſtill cracks and chaſms through the whole ſurface of the bog, which contains forty acres.

But we have a later incident of the ſame kind. On Saturday, January 26, 1745, a part of Pilling-moſs, lying near Heſcomb-houſes, was obſerved to riſe a ſurpriſing height. After a ſhort time it ſunk as much below the level, and moved ſlowly toward the ſouth-ſide. In half an hour it covered twenty acres of land. The improved land, adjoining to that part of the bog, is a concave circle, containing near a hundred acres, which is well nigh filled up with bog and water. In ſome parts, it is thought to be five yards deep.

An intenſe froſt retards its progreſs for the preſent, but it is likely to ſpoil a great deal more land. That part of the moſs, which is ſunk like the bed of the river, runs north and ſouth. It is above a mile in length, and near half a mile in breadth.

Perhaps ſome moraſſes have been ever ſince the deluge. In ſome of theſe are found, many feet deep, whole foreſts of timber, and frequently of ſuch ſorts as have not grown in thoſe countries for many ages.

But ſome moraſſes are only of late date. Lord Cromartie gives a remarkable account, of what he himſelf obſerved with regard to the generation of ſuch a moraſs. In the pariſh of Lockburn, he ſaw, near the top of a very high hill, a plain about a mile over. It was then covered with a ſtanding wood, but ſo old, that the trees had neither leaves or bark left. When he came by the place fifteen years after, he obſerved all the trees were fallen. A few years after that, they were quite covered over with a ſoft, ſpongy earth, which

which formed a proper bog or moraſs. Many have been formed the ſame way.

The diſcovery of the bones of elephants at the bottom of ſome of our Engliſh bogs, ſeems a convincing proof, that the earth has undergone ſome very extraordinary alterations. For the remains of animals of quite different climates, which in the preſent ſituation of the world, could never poſſibly come over hither, muſt imply their having been originally here, or that England was once joined to the continent. But ſince we find theſe creatures only in the very hot countries, it is highly probable, they were not originally here, unleſs we ſuppoſe the temperature of our climate to have been greatly altered. And without ſuch a ſuppoſition, we cannot ſuppoſe they would have wandered hither, though all parts of the globe had been contiguous. But what changes have happened to our earth, no human wiſdom can find out. Suppoſe only the axis thereof to have been ſhifted at any time but a few degrees, what convulſions in nature, what an univerſal change in the face of things muſt have enſued? What inundations of water, bearing every thing before them? What breaches in the earth, what hurricanes and tempeſts, muſt have attended ſuch an event? For the waters muſt have rolled along, till an equipoiſe was produced. And all parts of the world muſt acquire different degrees of heat and cold from what they had before. Seas would be formed, where continents had been; continents torn in pieces, or ſplit into iſlands. Such would have been the fate of inanimate things. And as to living creatures they muſt have been deſtroyed and buried in the ruins of the world, as perhaps theſe elephants were.

CHAP.

CHAP. II.

1. *Of the Effects and Nature of Fire.*
2. *Of the Generation and Nouriſhment of it.*
3. *Of Smoke and Aſhes.*
4. *Of burning Mountains.*
5. *Of Mount Ætna.*
6. *Of Mount Veſuvius.*
7. *Of Monto Secco.*
8. *Of Monte Nuevo.*
9. *New Iſlands.*
10. *Burning Iſlands.*
11. *Of Mount Hecla.*
12. *Of Guadelope.*
13. *Of the Pike of Teneriff.*
14. *Of Earthquakes.*
15. *Deſtruction of Port-Royal in Jamaica.*
16. ——————— *Lima.*
17. ——————— *Calloo.*
18. *A remarkable Deliverance.*
19. *Of Pools and of Eldon Hole.*
20. *Earthquakes cauſed by Electricity.*
21. *Account of a burning Well.*
22. ——————— *one near Broſely.*
23. *A Fire of the ſame kind.*
24. *A burning Vapour.*
25. *Perſons conſumed by internal Fire.*
26. *Sparkles from a Perſon's Clothes.*
27. *Of Glaſs.*
28. *Of the Bologna Phial.*
29. *Of the Glaſs-drop.*
30. *Of the Nature and properties of Air.*
31. *Air in all our fluids.*
32. —— *is the cementing and diſſolving Principle.*

33. *Air increaſes the weight of Oil and Vitriol.*
34. — *capable of immenſe expanſion.*
35. *Difference between fixed & common Air.*

1. THE effects of fire are various. It heats, it ſhines, it expands, it diſſolves other bodies either by melting or reducing them to aſhes or a calx. Moſt of theſe argue a vehement motion of its particles, which tears aſunder whatever it ſeizes. It ſeems to be a moſt ſubtle matter, diſperſed throughout the univerſe. Yet this, even when collected ſoon ſcatters again, unleſs it be detained by ſome inflammable matter. Not that fire will ſpring from every motion: it muſt be circular, as well as rapid. For if particles move ever ſo ſwift in a ſtraight line, no fire will follow.

Heat ſeems to be nothing but motion: but this motion has ſome peculiar circumſtances. 1. It is expanſive motion, whereby a body endeavours to dilate itſelf. 2 This motion is upward, and toward the circumference: 3. It is not an equable motion of the whole, but only of the ſmaller particles of the body: 4. It is a rapid motion. Heat may therefore be defined, an expanſive, undulatory motion in the minute particles of a body, whereby they rapidly tend to the circumference, and at the ſame time upward.

Fire has ſome effect on moſt bodies, even in an exhauſted receiver. One placed a black ribbon therein, and then applied a burning-glaſs. Abundance of ſmoke iſſued out of it, which fell by little and little, and the ribbon appeared not at all changed. But when it was touched, after the re-admiſſion of the air, it preſently fell into aſhes.

The glaſs being applied to gun-powder ſo incloſed, it burnt grain by grain, but none of the grains kindled. Another time when the ſun had leſs force, they would not burn, but only boiled and emitted ſmoke. This ſmoke falling on the board on which the powder lay, was of the colour of brimſtone. The powder that remained, being put on coals, burned like ſalt-petre, inaſmuch as the brimſtone had exhaled.

Tin and copper melted together weigh more than both

both bodies did before. Yea, Orpin being mixed with ſalt of Tartar, is heavier by a fifth part.

To account for this, it has been commonly ſuppoſed, that fire adds to the weight of bodies. But fire has itſelf no weight at all: therefore it can give none. Pure fire, as Dr. Hillary obſerves, is a body without gravity, and has no more tendency to any one part of ſpace, than to any other.

Is not then this alteration of weight rather owing to an alteration of the inward texture of the particles in the body calcined? The lighter particles being removed by exhalation, do not thoſe remaining approach nearer each other? And muſt not then the weight, which is always as the ſolidity, increaſe accordingly?

It ſeems ſtrange, to talk of heating cold liquors with ice. Yet it may be eaſily done thus. Out of a baſon of cold water, wherein ſeveral fragments of ice are ſwimming, take one or two, and plunge them into a wide-mouthed glaſs of ſtrong oil of vitriol: this quickly melts the ice, and by two or three ſhakes, the liquor grows ſo hot, that frequently you cannot endure to hold the phial in your hand.

It may ſeem as ſtrange, that thoſe parts of the earth, which are neareſt the ſun ſhould be intenſely cold. Yet ſo it is. For the higher you aſcend on mountains, the colder is the air. And the tops of the higheſt mountains in the moſt ſultry countries are eternally clothed with ſnow. This is partly owing to the thinneſs of the air, partly to the little ſurface of earth there, to reflect the ſolar rays.

Very different degrees of heat, obtain in the ſame latitude, on the different ſides of the South American Continent: which ſhews that the temperature of a place depends much more upon other circumſtances, than upon its diſtance from the pole, or nearneſs to the equinoctial. Thus though the coaſt of Brazil is extremely ſultry, yet the coaſt of the South Seas in the ſame latitude is quite temperate, and in ranging along it, one does not meet with ſo warm weather, as is frequent in a ſummer's day in England: which is the more extraordinary, as there never falls any rain to refreſh and cool

the

the air. On the coaſt of Peru, even under the line, every thing contributes to make the day agreeable. In other countries, the ſcorching ſun in ſummer, makes the day unfit either for labour or amuſement: and the rains are no leſs troubleſome, in the cooler parts of the year. But in this delightful climate, the ſun rarely appears; for there is conſtantly a grey, cheerful ſky, juſt ſufficient to ſcreen the ſun, without obſcuring the air. Thus all parts of the day are proper for labour, while the coolneſs produced elſewhere by rains, is here brought about by freſh breezes, from the cooler regions.

This is chiefly owing to the Andes, which running not far from, and nearly parallel with the ſhore, and riſing immenſely higher than any other mountains in America, form on their ſides a prodigious tract of land, where according to their different heights, all kinds of climates may be found, at all ſeaſons of the year. Theſe mountains intercept great part of the eaſtern winds, which generally blow on the continent of America, cool that part of the air which comes over their tops, and keep it cool by the ſnows, with which they are always covered. Thus by ſpreading the influence of their frozen creſts, to the neighbouring coaſts and ſeas, they cauſe the temperature and equability which conſtantly prevail there. But when they leave theſe mountains, they experience in a ſhort time an entire change of climate, and in two or three days paſs from the temperate air of Peru, to the ſultry atmoſphere of the Weſt Indies.

The ſparks which appear on ſtriking fire with a flint and ſteel, are diſcovered by the microſcope, to be ſo many ſpherical balls of iron, detached by the blow from the maſs. They are then red hot. After they cool, they are a ſort of ſcoriæ or droſs.

2. Fire is generated chiefly, either by collecting the ſun-beams by a glaſs, or by rubbing hard bodies againſt each other. Either way the ſubtle matter is collected from all ſides, and put into a rapid, circular motion. This continues together, as long as it is ſupplied with inflammable ſubſtances. The particles of theſe being

being divided by the fire, are ſcattered hither and thither, and the fire goes out unleſs freſh fuel be brought: as it does if air be wanting. For as that ſubtle matter is diſſipating continually, it ſoon fails, unleſs recruited from the air. If water or duſt be thrown upon fire, it is likewiſe quickly extinguiſhed. For theſe interrupt that internal motion, which is eſſential to it.

That fuel cannot conſume without air is clearly proved by an eaſy experiment. Let a ſtrong, hollow cylinder of iron, be fitted with a firm ſcrew at each end. Incloſe in this a piece of charcoal: then ſcrew up both ends, and place it in a ſtrong fire. Let it ſtay there as long as you will. Open it when cool, and the charcoal is no way diminiſhed. It is plain from this, that the conſumption of fuel depends on the rarefaction and agitation of its parts by freſh air. And hence we have the reaſon of the known method, of extinguiſhing fires by ſmothering them.

3. The watry part of the fuel being rarefied by the heat, aſcends in the form of ſmoke, carrying with it many of the lighter particles, which adhere as ſoot to the chimney. The groſſer and more compact, the contexture whereof the fire cannot wholly deſtroy, remain and conſtitute aſhes, which are of conſequence extremely porous, all that was combuſtible in it being conſumed.

To enlarge a little on this ſubject. Fire is a body, and a body in motion. It is in motion; for it expands the air, which can no otherwiſe be done, than by communicating motion to it. And that it is a body appers hence. Pure mercury incloſed in a phial, and kept in a gentle heat for a year, is reduced into a ſolid. And its weight is conſiderably increaſed, which can only ſpring from the acceſſion of fire.

Fire is the inſtrument of all the motion in the univerſe. Without it all bodies would become immoveable. Men would harden into ſtatues: and not only water, but air cohere into a firm, rigid maſs.

As it is in itſelf, it is termed elementary fire: joined with other bodies it is called culinary. The minute particles of this, joining with thoſe of the pure fire, conſtitute what is termed flame. Pure fire, ſuch as is collected by a burning glaſs, yields no flame, ſmoke,

ſmoke, or aſhes. In itſelf it is imperceptible, but is diſcovered by its effects. The firſt of theſe is heat, which ariſes wholly from fire, and the meaſure of heat is always as the meaſure of fire. The ſecond is, dilatation in all ſolid, and rarefaction in all fluid bodies. So an iron rod, the more it is heated, increaſes the more in all its dimenſions. And by the ſame degrees that it cools, it contracts, till it ſhrinks to its firſt magnitude. So gold, when fuſed takes up more ſpace than it did before. And mercury aſcends in a hollow tube over the fire, to above thirty times its former height. The ſame degree of heat rarefies fluids ſooner, and in a greater degree than it does ſolids. And the lighter the fluid, the more it is dilated. Thus air, the lighteſt of all fluids, expands the moſt. The third effect of fire is motion: for in dilating bodies, it muſt needs move their parts. All motion ſprings from it. Only take fire away, and all nature would grow into one concrete, ſolid as gold, and hard as diamond.

Pure fire needs no air to ſuſtain it. Put calx of tin into an exhauſted receiver, and if you apply a burning-glaſs, the calx will be ſo vehemently dilated, as to break the receiver into a thouſand pieces.

All the effects of elementary fire may be increaſed. 1. By rubbing one body againſt another. And the more hard and ſolid the bodies are, the more heat is produced. So ſponges rubbed together acquire little or no heat: but two pieces of iron, an intenſe heat. 2. By mixing certain bodies together. So ſteel-filings mixed with oil of cloves or ſpirit of nitre grow exceeding hot; yea, burſt into a violent flame.

Yet it does not appear that any new fire is generated in any of theſe ways. Friction does not create fire, but only collects what was before diſperſed. It is preſent every where, in all bodies, in all ſpace, at all times, and that in equal quantities. Go where you will, to the higheſt mountain, or the deepeſt cavern, by one or other of theſe ways fire may be collected. Yea, there is no place in the world, where the attrition of two ſticks will not make it ſenſible.

But in what manner ſoever fire is collected, if the collecting cauſe ceaſe, it diſappears again, unleſs it be ſupplied with fuel, and then it becomes culinary fire.

By

By fuel we mean whatever receives and retains fire, and is conſumed thereby. The only fuel in nature is oil or ſulphur, and bodies are only fuel, as containing oil. Hence 1. All vegetables not too moiſt or too dry, afford fuel, particularly thoſe which contain much oil, as balſamic and reſinous woods. 2. All vegetable and animal coals, being thoſe parts which have exhaled their water and ſalt, and retained the oil alone inhering in the earth. 3. All bituminous earth. 4. All mineral ſulphur, whether pure or joined with other things. 5. The fat and dung of animals: and 6. Chymical oil and ſpirits.

On the removal of air, this fire goes out. Yet it does not immediately bear the air, but repels it, and by that means forms a kind of vault, which by its weight, and the preſſure of the incumbent air, confines the particles that would otherwiſe eſcape, and applies them to the combuſtible matter. Hence the heavier the air, the fiercer the fire; which therefore is fierceſt in ſtill, cold weather.

The fire in burning combuſtible matter, affords a ſhining fire or flame, or both: and frequently too, ſmoke, ſoot and aſhes. Shining fire ſeems to be elementary fire, ſo ſtrongly attracted toward the particles of the fuel, as to whirl, divide, attenuate them, and thus render them volatile, and juſt fit to be expelled. Flame ſeems to be the moſt volatile part of the fuel, greatly rarefied and heated red hot. Soot is a ſort of coal, conſiſting of a thick ſulphur, and an attenuated oil, with earth and ſalt. Smoke is the earthy and watry particles of the fuel, ſo rarefied as to break through into the atmoſphere. Aſhes are the earth and ſalt, which the fire leaves unchanged.

Fire increaſes the weight of ſome bodies. Thus if antimony be placed under a burning-glaſs, the greateſt part of it will ſeem to evaporate in fumes, and yet if it is weighed, it will be found to have gained in weight.

But beſide the ſolar, there is a ſubterraneous fire. The earth is only cold to the depth of forty or fifty feet. Then it begins to grow warmer; and at a great depth it is ſo hot as to deſtroy reſpiration. Hence we

learn

learn that there is another ſource of fire, or as it were another ſun in the boſom of the earth.

Upon the application of fire to water, it boils: that is, the particles of fire, paſſing through the pores of the veſſel, ſtrike on the loweſt particles of the water, impel them upwards, and render them lighter than before, both by inflating them into little veſicles, and by breaking and ſeparating their ſpherules. There will of conſequence be a conſtant flux of water, from the bottom of the veſſel to the top. And hence we ſee, why the water is hot at the top, ſooner than at the bottom.

Farther, the air contained in the interſtices of the water being dilated, and its ſpring increaſed by the heat, it aſcends through the water into the air, carrying with it the contiguous particles of water. And by this means much of the water will be heaved up, and let fall alternately, as the air has no power to carry away into the atmoſphere more than that ſmall part that riſes in the ſteam.

4. That this ſubtle matter is plentifully collected in the bowels of the earth, appears from burning mountains. It is obſerved, that there is always in the neighbourhood of theſe, plenty of ſulphur or bitumen, the ſtench whereof ſpreads far and near, eſpecially before any great eruption. This feeds the fire, which may be kindled by various means, ſo as to continue for many centuries. Ætna and Veſuvius have burned for above 2000 years, and probably will till the end of time.

5. Mount Ætna is divided into three diſtinct regions, called La Regione Culta: the fertile region: La Regione Sylvoſa, the woody region; and La Regione Deſerta, the barren region.

The three are as different, both in climate and productions, as the three zones of the earth; and perhaps with equal propriety might have been ſtiled the torrid, the temperate, and the frigid zone. The firſt region ſurrounds the foot of the mountain, and conſtitutes the moſt fertile country in the world on all ſides of it, to the extent of about fourteen or fifteen miles, where the woody region begins. It is compoſed almoſt entirely

tirely of lava, which, after a number of ages, is at laſt converted into the moſt fertile of all ſoils.

Every eruption generally forms a new mountain. As the great crater of Ætna itſelf is raiſed to ſuch an enormous height above the lower regions of the mountain, it is not poſſible that the internal fire raging for vent, even round the baſe, and no doubt vaſtly below it, ſhould be carried to the height of twelve or thirteen thouſand feet to the ſummit of Ætna. It has therefore generally happened, that after ſhaking the mountain and its neighbourhood for ſome time, it at laſt burſts open its ſide. At firſt it only ſends forth a thick ſmoke and ſhowers of aſhes, that lays waſte the adjacent country: theſe are ſoon followed by red-hot ſtones, and rocks of a great ſize, thrown to an immenſe height in the air. The fall of theſe ſtones, together with the quantity of aſhes diſcharged at the ſame time, at laſt form one of theſe ſpherical and conical mountains. Sometimes this proceſs is finiſhed in the courſe of a few days: ſometimes it laſts for months, which was the caſe in the eruption in 1669. In that caſe the mountains formed are of a great ſize; ſome of them are not leſs than ſeven or eight miles round, and upwards of one thouſand feet in perpendicular height: others are not more than two or three miles round, and three or four hundred feet high.

After the new mountain is formed, the lava generally burſts out from its lower ſide; and bearing away every thing before it, is for the moſt part terminated by the ſea. This is the common progreſs of an eruption; however it ſometimes happens, though rarely, that the lava burſts at once from the ſide of the mountain, without all theſe attending circumſtances; and this is commonly the caſe with the eruption of Veſuvius, where the elevation being much ſmaller, the melted matter is generally carried up into the crater of the mountain, which then diſcharges ſhowers of ſtones and aſhes from the mouth of the volcano, without forming any new mountain, but only adding conſiderably to the height of the old one; till at laſt the lava, riſing near the ſummit, burſts the ſide of the crater, and the eruption is declared. This has been the caſe with two eruptions lately; but Ætna is upon a much

larger

larger ſcale, and one crater is not enough to give vent to ſuch oceans of liquid fire.

A Sicilian gentleman ſaw in an eruption of that mountain, large rocks of fire diſcharged to the height of ſome thouſand feet, with a noiſe more terrible than that of thunder. He meaſured from the time of their greateſt elevation, till they reached the ground, and found they took twenty-one ſeconds to deſcend, which (the ſpaces being as the ſquares of the times) amounting to upwards of 7000 feet.

After contemplating theſe objects for ſome time, ſays a late traveller, we ſet off, and ſoon after arrived at the foot of the great crater of Ætna. This is of an exact conical figure, and riſes equally on all ſides. It is compoſed ſolely of aſhes, and other burnt materials, diſcharged from the mouth of the volcano, which is in its centre. This conical mountain is of a very large ſize: its circumference cannot be leſs than ten miles. Here we took a ſecond reſt, as the greateſt part of our fatigue ſtill remained. The mercury had fallen to 20 4½. We found this mountain exceſſively ſteep; and although it had appeared black, yet it was likewiſe covered with ſnow, but the ſurface (luckily for us) was ſpread over with a pretty thick layer of aſhes, thrown from the crater. Had it not been for this, we never ſhould have been able to get to the top.

The circumference of this zone or great circle on Ætna is not leſs than ſeventy or eighty miles. It is every where ſucceeded by the vineyards, orchards and corn-fields that compoſe the Regione Culta, or the Fertile Region. The laſt zone is much broader than the others, and extends on all ſides to the foot of the mountain. Its whole circumference, is 183 miles.

The preſent crater of this immenſe volcano is a circle of about three miles and a half in circumference. It goes ſhelving down on each ſide, and forms a regular hollow, like a vaſt amphitheatre. From many places of this ſpace, iſſue volumes of ſulphureous ſmoke, which being much heavier than the circumambient air, inſtead of riſing in it, as ſmoke generally does, immediately on its getting out of the crater, rolls down the ſide of the mountain like a torrent, till coming to that part of the atmoſphere of the ſame

ſpecific

ſpecific gravity with itſelf, it ſhoots off horizontally; and forms a large tract in the air, according to the direction of the wind; which happily for us, carried it exactly to the ſide oppoſite to that where we were placed. The crater is ſo hot that it is very dangerous, if not impoſſible, to go down into it: beſides the ſmoke is very incommodious, and in many places the ſurface is ſo ſoft, there have been inſtances of people ſinking down into it, and paying for their temerity with their lives. Near the centre of the crater is the great mouth of the volcano, that tremendous gulf ſo celebrated in all ages. We beheld it with awe, and with horror, and were not ſurpriſed that it had been conſidered as the place of the damned. When we reflect on the immenſity of its depth, the vaſt cells and caverns whence ſo many lavas have iſſued; the boiling of the matter, the ſhaking of the mountain, the exploſion of flaming rocks, we muſt allow that the livelieſt imagination hardly ever formed an idea of hell more dreadful.

Kircher pretends to have meaſured it, and to have found it four thouſand French toiſes in height: which is more than any of the Andes are. The Italian mathematicians are ſtill more abſurd. Some of them make it eight miles, ſome ſix, and ſome four. Arnici, the laſt, and I believe the beſt who has made this attempt, reduces it to three miles, two hundred and ſixty-four paces; but even this muſt be exceedingly erroneous, and probably the perpendicular height of Ætna is little more than two miles.

It is a curious conſideration that this mountain ſhould re-unite every beauty and every horror; and in ſhort, all the moſt oppoſite and diſſimilar objects in nature. Here you obſerve a gulf, that formerly threw out torrents of fire now covered with the moſt luxuriant vegetation; and from an object of horror becomes one of delight. Here you gather the moſt delicious fruits, riſing from what was lately a black and barren rock. Here the ground is covered with every flower; and we wander over theſe beauties, and contemplate this wilderneſs of ſweets without conſidering that hell and all its terrors, immediately under our feet, and that but few yards ſeparate us from lakes of liquid fire and brimſtone.

But our aſtoniſhment ſtill increaſes, on caſting our eyes on the higher regions of the mountain. There we behold in perpetual union, the two elements that are at perpetual war; an immenſe gulf of fire, for ever exiſting in the midſt of ſnows, which it has not power to melt; and immenſe fields of ſnow and ice for ever ſurrounding this gulf of fire, which they have not power to extinguiſh.

The quantity of matter diſcharged from Ætna, is ſuppoſed upon a moderate computation to exceed twenty times the original bulk of the mountain. The greateſt part of Sicily ſeems covered with its eruptions. The inhabitants of Catanea have found at the diſtance of ſeveral miles, ſtreets and houſes, ſixty feet deep, overwhelmed by the lava, or matter it has diſcharged: nay the walls of theſe very houſes have been built of materials, evidently thrown up by the mountain. The inference is obvious: that the matter thus exploded cannot belong to the mountain itſelf: otherwiſe it would have been quickly conſumed: it cannot be derived from moderate depths; ſince its amazing quantity evinces that all the places near the bottoom, muſt have long ſince been exhauſted: it muſt therefore be ſupplied from the deeper region of the earth; theſe undiſcovered tracts, where the Deity performs his wonders in ſolitude.

An eruption of Mount Ætna, in 1669, was preceded for eighteen days, with a dark, thick ſky, thunder, lightning, and frequent tremblings of the earth. The place of eruption was twenty miles from the old mouth: the matter of it was a ſtream of melted minerals, boiling up and guſhing out, as water does at the head of a great river. Having run thus for more than a ſtone's caſt, the extremities began to cruſt, and turn into porous ſtones, reſembling huge cakes of ſea coal, full of a fierce fire. Theſe came rolling over one another, and where any thing oppoſed, filled up the ſpace and rolled over. But they bore down any common building, and burnt up all that was combuſtible. This inundation went on about a furlong a day, for nineteen or twenty days. It overwhelmed fourteen towns and villages. The noiſe of the eruption was heard ſixty miles.

On

On Sunday, March 9, 1755, about noon, Mount Ætna began to caſt from its mouth a great quantity of flame and ſmoke, with a moſt horrible noiſe. At four o'clock, the air became quite dark, and covered with black clouds. At ſix a ſhower of ſtones, each weighing about three ounces, began to fall over all the city of Maſcali and its territories. This ſhower laſted till a quarter paſt ſeven, and was ſucceeded all night by a ſhower of black ſand. On Monday morning, at eight, there ſprang from the bottom of the mountain a river of ſcalding-hot water, which in half a quarter of an hour, overflowed all the rugged land that is near the foot of the hill, and ſuddenly going off left the whole a large plain of ſand. The ſtones and ſand which remain wherever this water reached, differ in nothing from the ſtones and ſand of the ſea, and have even the ſame ſaltneſs. After the water was gone there ſprang from the ſame opening a ſmall ſtream of fire, which continued for four and twenty hours. On Tueſday, about a mile below this opening, there aroſe another ſtream of fire, which being in breadth about four hundred feet, overflowed all the adjacent country.

6. On the 3d of December, 1754, a ſtream of liquid fire, began to run down the ſide of Mount Veſuvius, from an opening on the eaſt-ſide. But it ſoon ceaſed running from this orifice, and burſt out from a much larger one, about two hundred yards below it. —Afterwards it burſt out from a third orifice, and having ran ſome ſpace with great fury, the ſurface then began to cool and incruſt, as it ran over gently-declining ground, till it came within about ten yards of the top of a ſteep declivity. Here the fire collected, as in a reſervoir, to ſupply a caſcade, which ruſhed down from thence in a chanuel of more than twenty feet wide, and about two hundred yards in length, with a fall of at leaſt fifty-feet. After this the ſtream was leſs rapid, but grew wider, and ſpread ſeveral miles from its ſource. It now preſented a very different ſcene from what it afforded before. The caſcade (ſays an eye-witneſs) looks like melted gold, and tears off large bodies of old lava (ſo they term

the incruſtation) which float down the ſtream, till the intenſeneſs of the heat lifts them from the bottom. But in the lower country, it divides into ſmaller ſtreams, running with leſs rapidity: and yet with ſuch violence, that it drives the ſtrongeſt ſtone fences before it, and lighting the trees, like torches, affords a moſt extraordinary, though diſmal ſpectacle.

On December 23, 1760, about two in the morning, a violent ſhock of an earthquake was felt, near Mount Veſuvius. Some time after, ſome countrymen being at work, four or five miles from it, perceived the ground near them on a ſudden heave and gape, like dough that is riſing. At the ſame time they obſerved ſmoke iſſuing from the clefts. They immediately fled, till they thought they were out of danger. And then looking back, ſaw the water of a ciſtern, near which they had been at work, ſpout out to a great height.—This was ſucceeded by a large diſcharge of fiery matter from the mouth of the ciſtern, and from four other openings, attended with a dreadful noiſe and exploſion of burning ſtones. On a ſudden all the fiery ſtreams united in one, flowed impetuouſly down the mountain, and gliding quick as lightning, preſently covered all the adjacent lands. Meantime the whole mountain ſhook greatly, and a fixed pillar of ſmoke iſſued out of the main aperture, which riſing to a certain height, then diſſolved into aſhes, and fell like rain all over the mountain. At the ſame time an immenſe quantity of burning ſtones was thrown out.

The fiery ſtream continued running down the mountain, the whole night between the 23d and 24th.—Houſes, gardens, and every thing in its way, were conſumed. And aſhes were ſtill thrown out, which lay deep on the ground for ſeveral miles about, and reached as far as the ſea-coaſt.

On the 25th alſo there was an eruption of liquid fire, with a ſhower of ſtones, and a huge noiſe. In ſeveral parts this ſtream was fifty ſpans deep. The mountain mean time continued to roar, and thick aſhes fell like rain over the whole country.

On the 26th both the mountain itſelf and the hills lately produced, ſent forth ſtones and aſhes, the bellowings were ſtill heard, but with intermiſſions: and out of the five apertures, two only continued to emit ſtones, aſhes, and fire.

On the 27th only one firey ſtream remained, and that began to cool, and to loſe its brightneſs, appearing more duſky, like burning coals ready to go out. —On the 28th the ſtream ran much ſlower, and no more burning ſtones were caſt out. The height of the chief hill raiſed thereby was about two hundred ſpans; and its circumferance about two hundred paces. The motion of the lava in front was very ſlow; it gained ground only on the ſides. The hill, where the laſt aperture was, burſt, and fire iſſued from all the fiſſures.

On the 29th, the lava having ceaſed, appeared to have reached about a mile in breadth and four miles in length. The new-raiſed hills were now quiet: but the top of Veſuvius ſtill caſt out aſhes and ſmoke, and ſome ſhowers of ſtones. About eight at night the new hill was overturned with a great crack, and on the 30th emitted nothing. But from the mouth of Veſuvius clouds and aſhes came in great abundance.— From the whole it appears, that the inflammatory contents take fire at a great depth in the cavern, and it is highly probable, it is the ſea-water which feeds this ſubterraneous fire, by means of ſome communications which the volcano has with the Mediterranean.

Although the fiery eruptions of Mount Veſuvius ſtrike the neighbourhood with horror; yet as even noxious things bring ſome advantage with them, ſo this mountain, by the ſulphureous and nitrous particles with which it manures the ground, and the heat of its ſubterraneous paſſages, much contributes to its common fertility. And wherever theſe inflammable ſubſtances abound, it is better they ſhould have a vent than not. So experience ſhews, that this country has had fewer earthquakes, and thoſe leſs fatal in their effects, ſince the eruption of the ſubterraneous matter, through the mouth of Veſuvius. And the inhabi-

tants

tants are not much alarmed, at ſeeing the uſual vernal exploſions.

The diſtance from Naples to the foot of Veſuvius, is five Italian miles, from whence to the top is near three miles further. It properly conſiſts of two hills, though only one of them emits fire and ſmoke. The valley between them is about a mile long, and extremely fertile. The burning ſummit, which is the loweſt of the two, is eleven hundred fathoms above the ſurface of the ſea. From Reſina, the aſcent grows ſteeper, and many ſtones are ſcattered about, as memorials of its former devaſtations. It is aſtoniſhing to think of the force, by which ſuch huge hulks of four or five hundred weight have been thrown ſeveral miles from the hill.

This being ſteep, and covered with black aſhes, the aſcent is very difficult. From the mouth frequently iſſues a flood of lava, or compoſition, of ſulphur, metals, and minerals. This ejected matter lies ſtill, one layer above another, with large ſtones projecting above the ſurface, which in their courſe along the fiery river, were ſtopped by their inequalities, and fixing in the melted matter, gradually hardened. Theſe ſtreams are not thrown up from the mountain, like the ſtones, but pour down as from an inclined veſſel, proceeding, it ſeems, from the whole cavity, which is then full of melted ſubſtances.

About half way up the mountain (ſays Mr. Keyſber) we met with ſtones of above a hundred weight, glowing hot, which when broken had exactly the appearance of red hot iron. As we went on, we heard a moſt horrid noiſe, reſembling the diſcharge of a whole battery of cannon, and under our feet we perceived a rumbling, like the boiling of a large caldron. At laſt we reached the place where the largeſt volcano was formerly ſituated. But it is now not only choaked up, but covered with a round pile of aſhes and lava. Thirty years ſince there was a plain of about three thouſand yards to croſs, before you came to the ſkirts of this new mountain. But it is now ſo enlarged, that in moſt places, the plain is but about thirty yards broad. Probably in a few years it will be quite filled up, and the two mountains joined in one. Here the increaſe of heat

heat was very ſenſible, eſpecially at every exploſion, when the aſhes flew ſo ſtrongly in our faces, that we were obliged to cover our eyes. The ground alſo was ſo hot under our feet, that it burnt the ſoles of our ſhoes. Every eruption was attended with a whizzing noiſe, like that of many rockets thrown up at once. The clouds of ſmoke and the multitude of ſtones thrown into the air, totally obſcured the ſky. Moſt of the ſtones, (eſpecially if large) fell again into the abyſs from which they were projected. Great quantities however fell on the ſides of the mountain, and rolled down with a hideous noiſe.

Even when all is ſtill, the bottom of the cavity is ſeldom ſeen, by reaſon of the ſmoke. When it is, it is ſubject to great variation. Sometimes it is of a prodigious depth; at other times hardly more than a hundred feet, according to the riſing or falling of the melted matter, ſince the laſt eruption, by the hardening of which, this bottom is formed.

Since the birth of Chriſt, there are recorded upwards of twenty memorable eruptions of Veſuvius. One of the moſt violent was, that which happened in the reign of Titus Veſpaſian, and deſtroyed the cities Herculaneum, Stabice and Pompeii, which then ſtood near Naples. During that eruption the aſhes were driven as far as Africa, Syria, and Egypt, and even at Rome, the ſun was darkened by them. Theſe cities were partly ſwallowed up, partly buried in the burning lava, ſo that not the leaſt remains of them were to be ſeen.

But within a few years many things have been dug out of Herculaneum, near Portici, the King of Naples' palace. Among theſe are many paintings done in ſtucco, in water colours in freſco. They have been taken from the walls of an amphitheatre, a temple, and ſeveral houſes, and are in great variety, ſome perfectly well preſerved.

Four capital pieces are ſo extremely well executed that Don Franceſco de la Vega, a painter, whom the King of Naples ſent for from Rome, to take draughts of theſe paintings, ſaid, "If Raphael were alive, he would be glad to ſtudy theſe drawings, and perhaps take leſſons from them." Nothing can be more juſt and

and correct. The muſcles are exactly and ſoftly drawn, every one in its own place, without any of that preternatural ſwelling ſeen in the works of ſome of the beſt Italian maſters. And it is ſurpriſing to ſee how freſh the colours are, conſidering they have been under the ground above ſixteen hundred and fifty years.

The matter thrown out of Veſuvius, ſhews whence its fiery eruptions ariſe. For, pour water, on ſulphur, mixed with filings of iron, and it ſoon breaks out into a flame. That abundance of ſulphur and iron is contained in Veſuvius, appears not only from what is ejected, but alſo from the mineral water, iſſuing from the foot of the mountain. The neighbouring ſea both ſupplies moiſture to theſe inflammable ſubſtances, and alſo ſalt and bitumen. That Veſuvius has a communication with the ſea, experience ſhews, the waters being ſurpriſingly abſorbed, in 1681, before the eruption, ſo that ſeveral veſſels before afloat were left dry. Likewiſe in 1698, the ſea ſuddenly ebbed twelve paces and the mountain diſcharged a torrent of bituminous matter. When the diſcharge ceaſed, and the ſea returned to its former height, great quantities of ſhells, half-burnt, and emitting a ſulphureous ſmell, were found along the ſhore. In another violent eruption, not only ſhells, but ſea-weeds, and hot ſea-water were ejected.

This volcano, however, affords ſeveral freſh ſprings, ſome of which are conveyed to Naples, by a beautiful aqueduct. Theſe waters have not the leaſt heat in them. Nay, a cold wind is felt to blow, from ſeveral fiſſures and chaſms of the mountain.

The whole country for twenty miles or more round Naples, is the product of ſubterraneous fires. Probably the ſea reached the mountains that lie behind Capua and Caſerta. Theſe fires ſeem to have worked under the bottom of the ſea, as moles in a field, throwing up here and there a hilloc. And the matter thrown out of ſome of theſe hillocs formed into ſettled volcanos, filling up the ſpace between them, has compoſed this part of the continent, and many of the iſlands adjoining.

Were the matter carefully examined, it would be found (juſt contrary to the common opinion) that moſt mountains which are or have been volcanos, owe their exiſtence to ſubterraneous fires.

It cannot be denied that Herculaneum and Pompeii once ſtood above the ground, though now the latter is buried ten or twelve feet deep; the former in no part leſs than ſeventy, in ſome parts a hundred and twelve. As theſe were buried by an eruption of Veſuvius, A. D. 79, it muſt be allowed, that whatever matter lies between them and the ſurface of the earth over them, muſt have been produced ſince this time.

Pompeii being farther off, felt the effects of a ſingle eruption only. It is covered with white pumice ſtones, mixed with fragments of lava and burnt matter. Over this there is a ſtratum of good mould, about two feet thick. The ſhower of pumice ſtones covered alſo the town of Stabiæ, with a tract of country thirty miles in circumference. It is obſervable, the pavement of the ſtreets of Pompeii is of lava: nay, under the foundation of the town, there is a deep ſtratum of lava and burnt matter: hence it is clear, there have been eruptions before that of 79, the firſt which is recorded in hiſtory.

The matter which covers Herculaneum, is not the produce of one eruption only. From the ſtrata of mould intermixed it appears, that five or ſix eruptions have taken their courſe over that which lies immediately above the town, with which the theatre, and moſt of the houſes are filled. This is not vitrified lava, but a ſort of ſoft ſtone, compoſed of pumice, aſhes, and burnt matter. It is of the ſame nature with what the Italians call tufa, and is in general uſe for building, and is met with only in thoſe countries that have been ſubject to ſubterraneous fires. As water frequeutly attends eruptions of fire, doubtleſs the firſt matter that iſſued from Veſuvius, and covered Herculaneum, was in the ſtate of liquid mud.

Braccini deſcended into the crater (or hollow on the top) of Veſuvius, a little before the eruption in 1631. He obſerves, it was then five miles in circumference, and about 1000 paces deep. Its ſides were covered with bruſh wood, and at the bottom there was a plain on which cattle grazed. In the midſt of this plain was a

narrow paſſage, through which by a winding path he deſcended among rocks and ſtones into a more ſpacious plain, covered with aſhes. In this were three little pools, one of hot water, bitter and corroſive beyond meaſure, another of water ſalter than that of the ſea; the third hot, but taſteleſs.

The great increaſe of the cone of Veſuvius, from that time to this, naturally induces one to think, that the whole cone was raiſed in like manner, as was alſo that part of it now called Somma. It ſeems, that this was what the ancients termed Veſuvius, and that the conical mountain, at preſent called by that name, has been raiſed by the ſucceeding eruptions.

From repeated obſervations, it appears, that all the ſoil in the neighbourhood of Veſuvius, is compoſed of different ſtrata of erupted matter, to a great depth below the level of the ſea. And undoubtedly this volcano took its riſe from the bottom of the ſea. The ſoil from Capreæ to Naples is of the ſame ſort. And that on which Naples ſtands, has been evidently produced by exploſions, ſome of them on the very ſpot whereon the city is built. All the high grounds round it, with the iſlands of Prochyta and Iſchia, appear likewiſe to have been raiſed in the ſame manner.

Such wonderful operations of nature, are certainly intended for ſome great purpoſe. They are not confined to one country; volcanos exiſt in the four quarters of the globe. We ſee the fertility of the ſoil occaſioned thereby, in what was thence called Campania felix. The ſame is evident in Sicily, juſtly eſteemed one of the moſt fertile ſpots in the world. May not ſubterraneous fire be conſidered as the great plough (if we may be allowed the expreſſion) which nature makes uſe of to turn up the bowels of the earth, and afford us freſh fields to work upon, when the former are exhauſted? Perhaps likewiſe many precious minerals might have remained unknown to us, had it not been for theſe operations of nature.

There is great reaſon to believe that the whole Iſland of Madeira was at ſome remote period thrown up by the exploſion of ſubterraneous fire, as every ſtone, whether

ther whole or in fragments, that is ſeen upon it appears to have been burnt; and even the ſand itſelf to be nothing more than aſhes. And it is certain, that part of the country near the ſea is a very exact ſpecimen of the reſt.

7. Near Puzzuolo lies Monte Secco, which is Veſuvius in miniature. Its ſummit, formerly a cone, is now ſunk into a concave oval, whoſe ſhorteſt diameter is about one thouſand feet, the longeſt one thouſand two hundred and forty-ſix. It is generally known by the name of Solfatara. Though Veſuvius is twelve miles diſtant, yet they have a communication with each other. Hence the ſubterraneous fire is quiet at Solfatara, when it has a vent at Veſuvius: whereas the heat at the former increaſes, when the latter is at reſt.

On this mountain are many cracks emitting ſmoke; the heat iſſuing from them is ſometimes inſupportable. Hold a piece of iron over one of theſe cracks, and a ſweetiſh fluid will drop from it: but a piece of paper, inſtead of being moiſtened, grows quite dry and ſtiff. The ſtones near theſe cracks are in continual motion; and ſmall ſtones dropped into them are ejected to the height of twelve feet, like the ponderous maſſes from Veſuvius. In ſome places the ſand by the force of the vapours, ſprings up and down, like the ſparkling of cyder.

Out of Solfatara they extract beſide ſulphur, blue vitriol, and the beſt kind of allum. The large leaden kettles uſed therein, are not heated by culinary fire, but by the natural heat, iſſuing through holes in the ground, over which the veſſels are placed.

8. Not far from Puzzuolo is Monte Nuovo, which roſe ſuddenly in the night, between the 19th and 20th of September, 1636. During a dreadful earthquake, that laid the whole neighbourhood in ruins, the ſubterraneous fire, opening a large chaſm in the ground, threw out ſuch quantities of ſtones, aſhes, bitumen, and ſand, as in twenty-four hours formed this mountain. Its perpendicular height is 400 rods, its circuit three miles. The edge of the firſt aperture is ſtill viſible, a mile in circuit, though it is now entirely filled up.

9. An

9. An event ſimilar to this occurred more lately. After a ſhock of the earth, there was ſeen from Santorini (an iſland in the Archipelago, on the coaſt of Natolia) on the 23d of May, 1707, as it were a floating rock. Some were ſo bold, as to go down upon it, even while it was riſing under their feet. The earth of it was very light and contained a ſmall quantity of potters clay. It increaſed daily, till it was half a mile in circumference, and twenty or twenty-five feet high. At this time a great ridge of rocks, dark and black, roſe out of the ſea, and joined to the new iſland. Then there iſſued out of it a thick ſmoke, with a noiſe like conſtant thundering, or a diſcharge of many cannon at once. The ſea water continually bubbled up; and in a ſhort time the new land preſented nothing to view for whole nights, but a great number of ſtoves, which caſt forth flames, with ſhowers of aſhes, and innumerable ſmall ſtones, red hot. Rocks were alſo darted out of theſe burning furnaces, which mounted up like bombs. This continued till November.

There is likewiſe an iſland among the Azores, which had the ſame original. On the night between the 7th and 8th of December, 1720, there was felt a ſhock of an earthquake at Tercera: and preſently after an iſland roſe, from the midſt of boiling hot water. It was nearly round, and high enough to be ſeen ſeven or eight leagues off. But after a little while it ſunk, till it became level with the water.

10. On June 4th, 1693, the mountain on the iſland Torca in the Eaſt-Indies, began about day-break, to caſt out more fire than uſual, which continued five or ſix days, till at laſt it poured forth, not only a prodigious flame, but likewiſe ſuch a black and ſulphureous vapour, that the inhabitants of Hiſlo (a village in the weſtern part of the iſland, and neareſt to the opening) were wholly covered by it. Quickly followed a ſtream of burning brimſtone, which conſumed many that could not eſcape. Afterwards the inhabitants perceived, a great part of the mountain was ſunk down. Another part ſunk three or four days after, and ſo from time to time, till the burning lake covered near half the iſland.

Wherefore

Wherefore they went on board their boats: from whence they perceived huge pieces of the mountain fall into the fiery lake, with a prodigious noiſe, as if a whole battery of cannon was diſcharged. The inhabitants of another town on the eaſt ſide of the iſland, not thinking themſelves in ſo great danger, remained a month longer. But the fiery lake approaching nearer and nearer, ſo that there was no doubt but it would ſwallow up the whole iſland, they too fled for their lives, and arrived at Amboyna, July the 18th, 1693.

In the mountains of Ternata, a terrible noiſe is continually heard. The fire frequently caſts out ſtones, and lies exceeding deep. Probably the burning mountains in the Molucca iſlands are conſumed beneath by the ſame fire.

Manilla is one of the largeſt of the Philippine iſlands. The city is much larger than Oxford, is an univerſity, and is inhabited only by Spaniards. The houſes are large, and built very ſtrong. The lower walls are ſtone, and of a prodigious thickneſs. All above is wood, and every piece of timber has a connexion with the others, and all are joined together, that the earthquakes which are very frequent may not throw them down. In 1750, they had an earthquake with almoſt continual tremblings for three months. Then followed an eruption in a ſmall iſland, ſurrounded by a large lake, which is unfathomable. The third day after the eruption began, there aroſe in the lake four more ſmall iſlands all burning. About a mile from one of theſe, there is a fire riſing continually out of the water, in a part where there is no ground for above a hundred fathom.

11. A particular account of a journey to Mount Hecla, is given by a late author. We travelled, ſays he, two days in rugged and unfrequented roads. Then we came within ſix miles of the mountain, and perceived the ground ſtrewed with aſhes and pumice ſtone, over which we paſſed to the foot of it. The weather being ſerene and calm, and no flames iſſuing out of the volcano, we reſolved to go to the top; till being informed

informed by our guides, that if we went any further, we ſhould be in danger of falling into pits, where we might be ſuffocated by the fumes riſing out of the earth, all my company declined it. I told them, if they would ſtay for me, I would go alone. They promiſed they would. So I alighted and prepared to go up, when one of them offered to go up with me.

Having given our horſes to our guides, who ſtayed with the reſt of our company, we ventured forward, reſolving to reach the top, and in a ſhort time ſaw a large flight of crows and vultures, that had their neſt in the top of the mountain. Having aſcended about half a league, we felt the ground ſhake under us, and heard a terrible noiſe in the bowels of the earth, juſt as if it was going to burſt open. At the ſame time there appeared on all ſides chinks, out of which iſſued bluiſh flames, with a ſtrong ſuffocating ſmell. This made us turn back, for fear of being burnt to aſhes. But we had ſcarce proceeded thirty yards back, before a black cloud of ſmoke aſcended out of the mountain, obſcured the light of the ſun, and covered us ſo thick, that we could not ſee each other. Our fears increaſed every ſtep we took; for behind us came flames of fire with ſhowers of aſhes and pumice ſtones, which fell as thick as hail. This dreadful ſtorm was attended with horrible noiſes, and we expected every moment, the earth would open and ſwallow us up. This added wings to our flight, ſo that in a quarter of an hour we got to the bottom of the mountain.

12. There are volcanos likewiſe in many of the American iſlands: and a very eminent one in Guadaloupe. The ſummit of this conſtantly emits ſmoke, and ſometimes flames. It riſes very high, in the form of a cone, above the chain of mountains, that occupy the centre of the iſland. Near the foot of it are three ſprings, the waters of which are ſo hot as to boil eggs in three minutes. The neighbouring ground ſmokes and is full of brown earth, like the droſs of iron. But the chief place where the ſmoke iſſues out, is higher up, at the foot of a ſteep bank, about fifty yards in breadth. Here no graſs is to be ſeen; nothing but ſulphur and calcined

calcined earth. The ground is full of deep cracks, which emit much ſmoke, and where you may hear the ſulphur boil. But the ſtench of it is intolerable. The ground is looſe, ſo that you may thruſt a cane up to the head. And when you draw it up, it will be as hot as if you had plunged it into ſlaking lime.

On the plain top of the hill is another funnel, that opened ſome years ſince, and emits nothing but ſmoke. Here are abundance of large and deep chinks, which doubtleſs burned in former times. In the middle of this plain is a very deep abyſs. It is ſaid there was once a great earthquake in the iſland, and that the Brimſtone Hill (ſo they call it) then took fire. It was probably then this abyſs was opened. It is between two crags that riſe above the mountain, and on the north ſide anſwers to the great cleft, which goes down above a thouſand feet perpendicular, is more than twenty feet broad, and penetrates above a hundred paces in the flat. So that in this place the mountain is fairly ſplit, from the top down to the baſis of the cone.

On this plain you may ſee the clouds gather below, and hear the thunder rumble under your feet. The great cavern is under the cleft, and was doubtleſs formed by the ſame earthquake that ſplit the mountain into two parts nearly equal. The parting goes north and ſouth. To the north is the cleft and cavern, in the middle the abyſs, and to the ſouth the burning gulf. The cavern is about twenty-five feet wide, as much in height, and about ſixty paces deep. Within this is a ſecond cave, about ſixty feet in length, as much in breadth, and forty in height. Here the heat is moderate: but there is a third cave within this, where it is ſo hot, that a torch will give no light therein, and a man can ſcarce fetch breath. Yet on the left is a great hollow, which is ſufficiently cool. And the ſpace of one fathom makes the difference. It ſeems ſtrange, that in the ſame cave, three hundred feet under ground, it ſhould be ſo hot on one ſide, and ſo cool on the other. Perhaps the cool ſide has ſome vent into the great cleft, and receives freſh air thereby.

13. Another ſurpriſing eminence, which may be ranked

ranked among burning mountains, is the Pike of Teneriffe. On the ſummit of it is a hollow, twelve or fourteen feet deep: the ſides ſloping down to the bottom, form a cavity like a truncated cone, with its baſe uppermoſt. This cavity is nearly circular, about forty fathoms acroſs. The ground is very hot, and from near twenty vents, iſſues a ſmoke of a ſtrong ſulphureous ſmell. The whole ſoil ſeems powdered with brimſtone, which forms a beautifully covered ſurface. Almoſt all the ſtones thereabouts are of a greeniſh colour, ſparkling with a yellow, like gold. On the middle of one of the rocks is a hole, about two inches in diameter. Hence proceeds a noiſe like that of a great body of liquors boiling very ſtrongly. And ſo hot a ſteam comes from it, as will burn the hand, even at a quarter of a yard's diſtance.

A ſmall part of the ſugar-loaf is white like lime; another ſmall part is covered with ſalt. But the far greateſt part is covered with ſnow, almoſt throughout the year.

The accounts given of its height are exceeding various. But a gentleman ſome years ago, who meaſured it exactly, found the perpendicular height to be two thouſand, five hundred and ſixty ſix fathoms.

14. When it happens that any inflammable ſubſtance takes fire in the caverns of the earth, the air contained therein is rarefied and exploded with an immenſe force. Hereby not only the arch which covers it, but the whole body of incumbent earth is ſhaken. And this is one ſpecies of earthquakes. In this caſe, the deeper the cavern is, and the larger the quantity of matter which takes fire, the more extenſive and the more violent the earthquake. If the cavern is near the ſurface of the earth, the fire often iſſues out of it: and the lower parts being eaten away, the ground ſinks in, and ſwallows up houſes or whole cities.

But, to conſider this point a little more minutely. As ſome earthquakes are owing to fire, ſo are ſome to air, others to water, and others to earth itſelf. 1. The earth itſelf may be the occaſion of its own ſhaking, when the root or baſis of ſome large maſs being worn away, that maſs ſinks in by its own weight, and cauſes a concuſſion

a concuſſion of all the neighbouring parts. 2. Subterraneous waters waſh away the foundations of hills, and eat far under the earth. By this means many earthquakes have been occaſioned, and whole cities ſwallowed up. This was undoubtedly the cauſe of the great earthquake at Port Royal, and of that which ſwallowed up Lima. 3. Air pent up in the bowels of the earth, if it be at any time rarefied and expanded, will ſtruggle for vent with incredible force, and thereby both ſhake and tear the earth. 4. But the uſual cauſe of the moſt violent earthquakes is ſulphur, or ſome other inflammable matter, taking fire in the cavities of the earth, and burſting through whatever oppoſes.

There are ſcarce any countries that are much ſubject to earthquakes, which have not ſome burning mountain. And whenever any earthquake happens, this is conſtantly in flames. Indeed were it not that theſe vents thus diſgorge the fire, it would make far greater havoc than it does; probably it would make the whole country for a vaſt ſpace round quite uninhabitable. Yea, ſo beneficial are theſe, that we do not want inſtances of countries frequently annoyed by earthquakes, which upon the breaking out of a volcano, have been wholly delivered from them.

Perhaps what cauſes moſt earthquakes of this kind is the Pyrites, or Iron-ſtone, which will take fire of itſelf. The earth, we know, abounds in cavities, which are at certain times full of inflammable vapours. This the damps in mines ſhew, which being fired, do every thing as in an earthquake, only in a leſs degree. And the Pyrites only, of all known minerals, yields this inflammable vapour. Nor is any mineral or ore whatever, ſulphureous, but what is more or leſs mixed with the Pyrites. But probably the Pyrites of the burning mountains, is more ſulphureous than ours. It is likewiſe in far greater quantities in all the countries round the Mediterranean than in England: a plain reaſon why earthquakes are ſo much more frequent and more violent there.

An artificial earthquake may be made thus. Add twenty pounds of ſulphur to twenty of iron-filings. Mix and temper theſe with water, ſo as to form a maſs of the conſiſtence of a firm paſte. Bury this three or four

four feet under ground. In ſix or ſeven hours time, the earth will begin to tremble, crack and ſmoke, and fire and flame will burſt through. So that there only wants a ſufficient quantity of this matter, to produce a true Ætna. If it were ſuppoſed to burſt out under the ſea, it might occaſion a new iſland.

To explain this point a little farther. This globe of earth is bored through with infinite cavities, which branching out like the veins, arteries, and nerves in our bodies, paſs under the very bottom of the ſea. Some of them ſerve to convey water, others a more unctuous ſubſtance, others an igneous matter, that gives motion to the whole frame.

Thus the exterior ſea communicates with the inmoſt abyſs, and paſſes to the roots of the hills and mountains. Mean time a conſtant air or wind, forces the water into the dark caverns, and receives and keeps alive a perpetual fire.

Have we not indubitable examples of theſe things? Does not the vaſt river Wolga, pour ſuch a quantity of water into the Caſpian Sea, within the ſpace of one year, as would be ſufficient, were there not ſome inviſible outlet, to cover the whole earth. This inviſible outlet is is a huge cavern, that paſſes under Mount Caucaſus into the Euxine ſea. Hereby the waters of the one ſea, diſcharge themſelves into the other. And the whole kingdoms of Georgia and Mengrelia, are as it were a bridge over thoſe ſubterraneous waters.

When the Caſpian ſea has been, on occaſion of winds, too much emptied into the Euxine, it is repleniſhed from the Perſian Gulf, which is a kind of reſervoir for it. And the ſubterraneous communication between the Red Sea and the Mediterranean is now out of all diſpute.

And how many inſtances of this have we in rivers? So late Geographers aſſure us, that the river Niger in Africa is derived from the river Nile, under the mighty chain of the mountains of Nubia: on the weſtern ſide of which mountains, it takes the name of Niger, and continues its courſe into the Atlantic ocean. So the vaſt and deep cave in Mount Taurus, receives the Tigris, and gives it a paſſage to the other ſide. The ſame river afterwards hides itſelf under ground, for

near

near twelve miles, and then breaking out again, diſembogues into the Euphrates, near Babylon.

To come nearer home; the Guadiana, that runs between Spain and Portugal, runs thirty-two miles under ground. Yea, in our own country, the Mole in Surry, falls into the ground near Boxhill, and riſes again at a conſiderable diſtance.

Hence we may ſafely collect that the earth is filled with ſubterraneous aqueducts and caverns, full of air and vapour and copious exhalations from all ſorts of minerals, as well as water.

Beſides theſe cavities, there are mountains whoſe bowels are in a continual flame. And their belching out aſhes, ſmoke, broken rocks and minerals, argue vaſt vacuities, and huge magazines of combuſtible matter, which are lodged therein. In the chain of mountains called the Andes in America, there are no leſs than fifteen volcanos, by whoſe burnings, caverns as big as whole kingdoms are made, and receive the cataracts of mighty rivers. And not only here, but over all the earth, there are ſo many channels, clefts and caverns, that we do not know, when or where we ſtand upon good ground. Indeed it might amaze men of a ſtout heart, could they ſee into the world beneath their feet, view the dark receſſes of nature, and obſerve the ſtrongeſt buildings ſtand upon an immenſe vault, at the bottom of which runs an unfathomable ſea, and whoſe upper hollows, are filled with ſtagnating air and the expirations of ſulphureous and bituminous matter.

Therefore as there are no large tracts of land, without volcanos and ſulphureous caverns, from which branching into ſmaller pipes, the ſubterraneous heat is conveyed throughout the earth: ſo no country can promiſe itſelf an entire immunity from earthquakes: even were there no other cauſe of theſe dreadful events, but ſubterraneous fires. Eſpecially, when it is conſidered, that the earth is in one part impregnated with ſulphur, in others with nitre, allum, vitriol, mercury, bitumen, oker and chalks. For if an artificial powder, made only of nitre, ſulphur and charcoal has ſo wonderful effects, what force muſt that combuſtible matter have, which ariſes from ſulphur, nitre, ſal-ammoniac, bitumen, gold, copper, iron, arſenic, mercury, and

other

other metallic and mineral ſpirits, with which the womb of the earth abounds, when the ſubterraneous fires break through into the hollow vaults, where theſe are repoſited by the God of nature? Then, according to the copiouſneſs of theſe combuſtibles, and the more or leſs firmneſs of the ſuper-incumbent earth, theſe fires cauſe tremblings and concuſſions, or violent eruptions: and perhaps open wide and deep gulfs, wherein whole cities, yea mountains are ſwallowed up.

Many ſuch inſtances occur in hiſtory. Pliny tells us, that in his own time, the mountain Cymbotus, with the town of Eurites, which ſtood on its ſide, were totally ſwallowed up. He records the like of the city of Tantelis in Magneſia, and after it of the mountain Sopelus, both abſorbed by a violent opening of the earth, ſo that no trace of either remained. Galanis and Garnatus, towns once famous in Phœnicia, are recorded to have met the ſame fate. Yea, the vaſt promontory called Phlegium in Ethiopia, after a violent earthquake in the night, was not to be ſeen in the morning, the earth having ſwallowed it up and cloſed over it.

Like inſtances we have of later date. The mountain Picus in one of the Molucca's, was ſo high, that it appeared at a vaſt diſtance, and ſerved as a land mark to ſailors. But during an earthquake in the iſle, the mountain in an inſtant ſunk into the bowels of the earth: and no token of it remained, but a vaſt lake of water. The like happened in the mountainous parts of China, in 1556: when a whole province, with all its towns, cities, and inhabitants was abſorbed in a moment; an immenſe lake of water, remaining in its place, even to this day.

In the year 1646, during the terrible earthquake in the kingdom of Chili, ſeveral whole mountains of the Andes, one after another, were wholly abſorbed in the earth. Probably many lakes of whoſe beginning we have no account, were occaſioned by the like abſorptions.

The greateſt earthquake we find in antiquity is that mentioned by Pliny, in which twelve cities in Aſia

Minor

Minor were ſwallowed up in one night. But one of thoſe moſt particularly deſcribed in hiſtory is that of the year 1693. It extended to a circumference of two thouſand ſix hundred leagues, chiefly affecting the ſea coaſt and great rivers. Its motions were ſo rapid, that thoſe who lay at their length were toſſed from ſide to ſide as upon a rolling billow. The walls were daſhed from their foundations, and no leſs than fifty four cities, with an incredible number of villages, were either deſtroyed or greatly damaged. The city of Catanea, in particular, was utterly overthrown. A traveller who was on his way thither, at the diſtance of ſome miles perceived a black cloud hanging near the place. The ſea all of a ſudden began to roar: Mount Ætna to ſend forth great ſpires of flame; and ſoon after a ſhock enſued, with a noiſe as if all the artillery in the world had been at once diſcharged. Our traveller being obliged to alight inſtantly, felt himſelf raiſed a foot from the ground, and turning his eyes to the city, ſaw nothing but a thick cloud of duſt in the air. Although the ſhock did not continue above three minutes, yet near nineteen thouſand of the inhabitants of Sicily periſhed in the ruins.

The following account of a dreadful earthquake at Calabria in 1638, is related by the celebrated Father Kircher, as it happened while he was on his journey to Mount Ætna.

" Having hired a boat in company with four more, we launched on the 24th of March from the harbour of Meſſina, and arrived the ſame day at the promontory of Pelorus. Our deſtination was for the city of Euphæmia in Calabria. But though we often put to ſea, we were as often driven back. At length however, we ventured forward. Proceeding onward, and turning my eyes to Ætna, I ſaw it caſt forth large volumes of ſmoke, which entirely covered the whole iſland. This together with the dreadful noiſe, filled me with apprehenſion. The ſea itſelf began to wear a very unuſual appearance, covered all over with bubbles. My ſurpriſe was increaſed by the calmneſs of the weather. I therefore warned my companions, that an earthquake was approaching, and making for the ſhore with all poſſible ſpeed we landed at Tropæ. But we had ſcarce

arrived

arrived at the Jeſuit's College in that city, when our ears were ſtunned with a horrid ſound reſembling that of an infinite number of chariots driven fiercely forward, the wheels rattling, and the thongs cracking. Soon after, the whole tract upon which we ſtood, ſeemed to vibrate, as if we were in the ſcale of a balance that continued wavering. This ſoon grew more violent, and being no longer able to keep my legs, I was thrown proſtrate upon the ground. In the mean time, the univerſal ruin round me, redoubled my amazement. The craſh of falling houſes, the tottering of towers, and the groans of the dying, all contributed to raiſe my terror. On every ſide of me, I ſaw nothing but a ſcene of ruin, danger threatening wherever I could fly. I recommended myſelf to God as my laſt refuge. At that hour, O how vain was every ſublunary happineſs! Wealth, honour, empire, wiſdom, all mere uſeleſs ſounds, and as empty as the bubbles on the deep. Juſt ſtanding on the threſhold of eternity, nothing but God was my pleaſure, and the nearer I approached, I only loved him the more. After ſome time, however, I reſolved to venture for ſafety, and running as faſt as I could, reached the ſhore. I did not ſearch long, till I found the boat in which I had landed and my companions alſo. Our meeting was all ſilence, and gloomy dread of impending terrors.

"Leaving this ſeat of deſolation, we proſecuted our voyage, and the next day landed at Rochetta, although the earth ſtill continued in violent agitations. But we were ſcarce arrived at our inn, when we were obliged to return to the boat, and in about half an hour, we ſaw the greateſt part of the town, and the inn at which we had ſet up, daſhed to the ground, and burying all its inhabitants beneath its ruins. Proceeding onward in our little veſſel, finding no ſafety at land, and yet having but a very dangerous continuance at ſea, we at length landed at Lapizium, a caſtle midway between Trapæa and Euphæmia. Here wherever I turned my eyes, nothing but ſcenes of ruin and horror appeared; towns and caſtles levelled to the ground: Strombalo, though at ſixty miles diſtance, belching forth flames in an unuſual manner. But my attention

was

was quickly turned to nearer danger. The rumbling ſound of an earthquake alarmed us. It every moment ſeemed to grow louder, and to approach more near. The place on which we ſtood, now began to ſhake moſt dreadfully, ſo that being unable to ſtand, my companions and I caught hold of the ſhrubs near us, and ſupported ourſelves in that manner.

"After ſome time this ſhock ceaſing, we ſtood up in order to go to Euphæmia, that lay within ſight. In the mean time, I turned my eyes towards the city, but could ſee only a dark cloud reſting upon the place. This the more ſurpriſed us, as the weather was ſo ſerene. We waited till the cloud was part away, then looking for the city, it was totally ſunk. Nothing but a putrid lake was ſeen where it ſtood. We looked about for ſome one that could tell us the ſad cataſtrophe, but could ſee none. All was become a melancholy ſolitude, a ſcene of hideous deſolation. Such was the fate of the city of Euphæmia. And as we continuued our melancholy courſe along the ſhore, the whole coaſt for the ſpace of two hundred miles preſented nothing but the remains of cities. Proceeding thus along, we at length ended our diſtreſsful voyage, by arriving at Naples."

15. Of the great earthquake at Port-Royal in Jamaica, an eye-witneſs writes thus. It happened on July 7, 1692, juſt before noon, and in the ſpace of two minutes, ſhook down and drowned nine tenths of the town. The houſes ſunk outright thirty or forty fathom. The earth opened and ſwallowed up the people, in one ſtreet, and threw them up in another: ſome roſe in the middle of the harbour. While the houſes on one ſide of a ſtreet were ſwallowed up, thoſe on the other ſide were thrown on heaps. The ſand in the ſtreet, riſing like waves in the ſea, lifted up every one that ſtood upon it. Then ſuddenly ſinking into pits, the water broke out, and rolled them over and over. Sloops and ſhips in the harbour were overſet, and loſt: the Swan frigate was driven over the tops of many houſes. All this was attended with a hollow rumbling noiſe. In leſs than a minute, three quarters of the houſes, with their inhabitants, were all ſunk under water:

water : and the little part which remained was no better than a heap of rubbiſh. The ſhock threw people down on their knees, or their faces, as they ran about to look for ſhelter. Several houſes which were left ſtanding, were removed ſome yards out of their places. One whole ſtreet was made twice as broad as before. In many places the earth cracked, opened and ſhut, with a motion quick and faſt. And two or three hundred of theſe openings might be ſeen at a time. In ſome of theſe people were ſwallowed up, in others caught by the middle and preſſed to death. In others the heads of men only appeared in which condition dogs came and ate them. Out of ſome of theſe openings, whole rivers of water ſpouted up a prodigious height : and out of all the wells the water flew, with a ſurpriſing violence. The whole was attended with a noiſome ſtench, and the noiſe of falling mountains at a diſtance, while the ſky in a minute's time turned dull and reddiſh, like a glowing oven. And yet more houſes were left ſtanding at Port-Royal, than in all the iſland beſide. Scarce a planter's houſe, or ſugar work was left throughout all Jamaica. A great part of them was ſwallowed up, frequently houſes, people and trees at one gap, in the room of which there afterwards appeared a large pool of water. This when dried up, diſcovered nothing but ſand, without any mark that houſe or tree had been there. Two thouſand people loſt their lives : had it been in the night, few would have eſcaped. A thouſand acres of land were ſunk : one plantation was removed half a mile from its place. Yet the ſhocks were moſt violent among the mountains. Not far from Yall-houſe, part of a mountain, after it had made ſeveral leaps, overwhelmed a whole family, and great part of a plantation, though a mile diſtant. A large mountain, near Port Morant, about a day's journey over, was quite ſwallowed up, and in the place where it ſtood, remained a lake, four or five leagues over. Vaſt pieces of mountains, with all the trees thereon, falling together in a confuſed manner, ſtopped up moſt of the rivers, till ſwelling abroad, they made themſelves new channels, tearing up every thing that oppoſed their paſſage, carrying with them into the ſea, ſuch prodigious

quantities

quantities of timber that they ſeemed like moving iſlands. In Liquania the ſea, retiring from the land, left the ground dry for two or three hundred yards. But it returned in a minute or two, and overflowed a great part of the ſhore. Thoſe who eſcaped from the town, got on board the ſhips in the harbour, where many continued two months: the ſhocks all the time being ſo violent, that they durſt not come on ſhore. The noiſome vapours occaſioned a general ſickneſs, which ſwept away three thouſand of thoſe that were left.

The following account of this memorable event is given by the Rector of Port-Royal.

On Wedneſday, June 7, I had been reading prayers, (which I have read every day ſince I came to Port-Royal, to keep up ſome ſhew of religion among a moſt ungodly people) and was gone to the preſident of the council. We had ſcarce dined, when I felt the ground heave and roll under me. I ſaid, "Sir, what is this?" He replied compoſedly, "It is an earthquake. Be not afraid; it will ſoon be over." But it increaſed more and more: and preſently we heard the church and the tower fall. Upon this we ran to ſave ourſelves; I quickly loſt him, and ran toward Morgan's Fort: as that was a wide open place, and ſecure from the falling of houſes. As I ran, I ſaw the earth open, and ſwallow up multitudes of people, and the ſea mounting over the fortifications. I then laid aſide all thought of eſcape, and went homeward to meet death in as good a poſture as I could. I was forced to go through two or three narrow ſtreets, the houſes fell on each ſide of me. Some bricks came rolling over my ſhoes, but none hurt me. When I came to my lodging, I found all things in the ſame order that I left them. I went to the balcony, and ſaw that no houſes in our ſtreet were fallen. The people ſeeing me, cried to me, to come and pray with them. When I came into the ſtreet, every one laid hold of my clothes and embraced me. I deſired them to kneel down in a ring, and prayed with them near an hour, till I was almoſt ſpent, between the exerciſe, and the heat of the ſun. They then brought me a chair, the earth working all

the time, like the rolling of the ſea, inſomuch that ſometimes while I was at prayers, I could hardly keep on my knees. By the time I had been half an hour longer with them, in ſetting their ſins before them, and exhorting them to repentance, ſome merchants came, and deſired me to go on board one of the ſhips in the harbour. From the top of ſome houſes, which lay level with the water, I got into a boat, and went on board the Siam Merchant. The day when this happened was exceeding clear, and afforded no ſuſpicion of evil. But about half an hour paſt eleven, in leſs than three minutes, Port-Royal, one of the faireſt towns in the Engliſh plantations, was ſhattered in pieces, and left a dreadful monument of the juſtice of God.

About ten years after the town was rebuilt, a terrible fire laid it in aſhes. Yet they rebuilt it once more. But in the year 1722, a hurricane reduced it a third time to a heap of rubbiſh. Warned by theſe extraordinary calamities, which ſeemed to mark it out as a devoted ſpot, they removed the public offices from thence, and forbade any market to be held there for the future.

16. Lima in Peru contains about 60,000 perſons. In 1747 an earthquake laid three fourths of the city level with the ground.

17. Callao, the Port of Lima, containing 3 or 4000 inhabitants was totally deſtroyed. Only one man eſcaped, and that by a very ſingular providence. He was going to ſtrike the flag on the fort, that overlooked the harbour, when he ſaw the ſea retire to a conſiderable diſtance, and then return, ſwelling mountains high. The inhabitants ran from their houſes, in the utmoſt degree of terror and confuſion. A cry for mercy aroſe from all parts: and immediately all was ſilent, the ſea had quite overwhelmed the city, and buried it for ever in its boſom. But at the ſame time it drove a little boat to the ſide of the fort, into which the man leaped and was ſaved.

18. Perhaps we have not in hiſtory, many more remarkable

markable deliverances than that of this good man. But more remarkable if poſſible, is the following deliverance, from a danger of a very different kind.

In the neighbourhood of Demonte, as one deſcends through the upper valley of Stura towards the middle of the mountain, there were ſome houſes in a place called Bergemolletto, which on the 19th of March, in the morning (there being then a great deal of ſnow) were entirely overwhelmed by two vaſt bodies of ſnow, that tumbled, down from the upper alps. All the inhabitants were then in their houſes, except one Joſeph Rochia, a man of about 50. Two and twenty perſons were buried under this maſs of ſnow, which was ſixty Engliſh feet in height. Many men were ordered to give them aſſiſtance; but were not able to do them the leaſt ſervice. After five days, Joſeph Rochia, got upon the ſnow, (with his ſon, and two brothers of his wife) to try if they could find the place under which his houſe and ſtable were buried; but they could not. However, the month of April proving very hot, and the ſnow beginning to melt, this unfortunate man was again encouraged to uſe his beſt endeavours. On the 24th, the ſnow was greatly diminiſhed, and he conceived hopes of finding out his houſe by breaking the ice. He thruſt down a long pole, but the evening coming on, he proceeded no farther. His wife's brother dreamed the ſame night, that his ſiſter was ſtill alive, and begged him to help her. He roſe early in the morning, told his dream to Joſeph and his neighbours, and went with them, to work upon the ſnow, where they made another opening, which led them to the houſe they ſearched for: but finding no dead bodies in its ruins, the ſought for the ſtable, which was about 240 Engliſh feet diſtant, and having found it, they heard a cry of "help, my dear brother." Being greatly ſurpriſed as well as encouraged by theſe words, they laboured till they had made a large opening, through which the brother went down, where the ſiſter with a feeble voice told him, "I have truſted always in God and you, that you would not forſake me." The other brother, and the huſband then went down, and found ſtill alive the wife about 45, the ſiſter about 35, and a daughter about 13 years of age. Theſe they

raiſed on their ſhoulders to men above, who pulled them up, and carried them to a neighbouring houſe; they were unable to walk, and ſo waſted, that they appeared like mere ſhadows.

Some days after the intendant came to ſee them, and they gave him the account that follows. In the morning of the 19th of March, we were in the ſtable, with a boy ſix years old, and a girl about 13. In the ſame ſtable were ſix goats, one of which had brought forth two dead kids the evening before; there were alſo an aſs and five or ſix fowls. We were ſheltering ourſelves in a corner of the ſtable, till the church-bell ſhould ring, intending to attend the ſervice. The wife wanting to go out of the ſtable to kindle a fire for her huſband, then clearing away ſnow from the top of the houſe, ſhe perceived a maſs of ſnow breaking down towards the eaſt, on which ſhe went back into the ſtable, ſhut the door, and told her ſiſter of it. In leſs than three minutes they heard the roof break over their heads, and alſo part of the ceiling of the ſtable. The ſiſter adviſed her to get into the rack and manger, which ſhe did very carefully. The aſs was tied to the manger, but got looſe by ſtruggling; and though it did not break the manger, it threw down the little veſſel which the ſiſter took up, and uſed afterwards to hold the melted ſnow, which ſerved them for drink. Very happily, the manger was under the main prop of the ſtable, and thereby reſiſted the weight of the ſnow. Their firſt care was to know what they had to eat; the ſiſter had in her pockets fifteen cheſnuts: the children ſaid they had breakfaſted, and ſhould want no more that day. They remembered there were 30 or 40 loaves in a place near the ſtable, and endeavoured to get at them, but were not able, by reaſon of the ſnow. On this they called out for help as loudly as they could, but no one heard them. The ſiſter came again to the manger, after ſhe had tried in vain to come at the loaves, gave two cheſnuts to the wife and eat two herſelf, and they drank ſome ſnow water. All this while the aſs continued kicking, and the goats bleated very much, but ſoon after, they heard no more of them. Two of the goats however were left alive, and were near the manger, they felt them carefully, and knew by ſo doing, that

one

one of them was big, and would kid about the middle of April; the other gave milk, wherewith they preſerved their lives.

The women affirmed, that during all the time they were buried, they ſaw not one ray of light; nevertheleſs, for about twenty days, they had ſome notion of night and day: for when the fowls crowed, they imagined it was break of day, but at laſt the fowls died. The ſecond day, being very hungry, they eat all the remaining cheſnuts, and drank what milk the goat yielded, which for the firſt days was near two pints a day, but the quantity decreaſed gradually. The third day, being very hungry, they again endeavoured to get to the place where the loaves were, but they could not penetrate to it. They then reſolved to take all poſſible care to feed the goats, as very fortunately over the ceiling of the ſtable, and juſt above the manger, there was a hay-loft with a hole, through which the hay was put down into the rack. This opening was near the ſiſter, who pulled down the hay, and gave it to the goats, as long as ſhe could reach it, which when ſhe could no longer do, the goats climbed upon her ſhoulders, and reached it themſelves. On the ſixth day the boy ſickened, complaining of violent pains in his ſtomach for ſix days, on the laſt of which he deſired his mother, who all this time had held him in her lap, to lay him at his length in the manger. She did ſo, and taking him by the hand, felt it was very cold: ſhe then put her hand to his mouth, and finding it likewiſe very cold, ſhe gave him a little milk; the boy cried, "O my father in the ſnow! Oh! father! father! and expired."

The mother told the ſiſter, the boy was dead, and then laid him in the manger where the ſiſter was. In the mean while the milk given by the goat diminiſhed daily. The fowls being dead, they could no longer diſtinguiſh night and day; but according to their calculation the time was near, when the other goat ſhould kid, which as they computed would happen about the middle of April. At length they found the goat was kidding by its cries, the ſiſter helped it; they killed the kid to ſave the milk for their own ſubſiſtence. And now they knew it was the middle of April. Whenever

ever they called this goat, it would come and lick their face and hands, and gave them every day two pints of milk, for which they ſtill bear a great affection to it.

During all this time, hunger gave them but very little uneaſineſs, except on the firſt five or ſix days. Their greateſt pain was from the extreme coldneſs of the melted ſnow-water, which fell on them; from the ſtench of the dead aſs, dead goat, and fowls; but more than all from the uneaſy poſture they were obliged to continue in. For though the place in which they were buried was twelve Engliſh feet long, eight wide, and five high, the manger in which they ſat ſquatting againſt the wall, was no more than three feet four inches broad.

19. May we not impute to earthquakes, thoſe huge cavities in the earth, which are found in ſeveral parts of England? Such is Poole's-hole about half a mile from Buxton, in Derbyſhire, ſaid to have been the refuge of one Poole, a noted robber. It is at the foot of a mountain: its entrance is low and narrow; but it preſently opens into a broad and lofty concavity, of above a mile in length. The water dropping from the roof, congeals into a kind of cryſtal, and forms a thouſand ſurpriſing figures. Here is alſo a large, clear ſtone, reſembling alabaſter, which the Queen of Scots, when here, called her pillar, and it ſtill goes by that name. Along the middle a ſtream of water falls among the rocks, which loudly echoes through the vault. The moſt ſtriking thing is, the height of the arch, and the ſpangled roof reſembling fret-work. And indeed the drops of water which petrifying, as they fall, form iſicles, reſembling cryſtal above, and pyramids hardened into ſtone below, have a ſurpriſing effect from the light of the candles: the hanging drops dazzling the eyes, as if this mighty arch was covered with diamonds.

Elden-hole is a frightful chaſm in the middle of a field, fifty or ſixty feet long, and about twenty broad. But how deep it is, could never be diſcovered, notwithſtanding all the attempts that have been made.

Mr.

Mr. Cotton endeavoured to fathom it with a line of ſixteen hundred yards; but in vain. Some ſuppoſe theſe to have been paſſages, whereby the waters of the deluge, returned from the ſurface of the earth to the great abyſs.

There is another effect of ſubterraneous fires, which has been generally imputed to quite different cauſes. The Giant's Cauſeway in Ireland, and all other ſtrong concretions of the ſame kind, where pillars are formed by pentagon, hexagon, or multangular ſtones, placed one upon another, are commonly ſuppoſed to be formed by a depoſition of ſtony matter from an aqueous fluid. On the contrary it is evident from various conſiderations, reſpecting their ſtructure and phænomena, that they are concretions of a peculiar kind, generated by an igneous fluid. They are peculiar to volcanic countries, and differ in every reſpect from the cryſtals produced by the ſlow and ſucceſſive precipitation of the ſtony particles contained in water. Their formation is owing to an intrinſic principle of organization, operating on an ignified fluid: on the concretion of which that principle may be ſuppoſed to have operated ſimultaneouſly in a large maſs, and to have produced theſe bodies in the ſame manner, as a linget of metal concretes at once in the mould.

In Perſia there is a ſubterraneous fire of a very harmleſs nature. It riſes out of the ground, about twenty miles from Baku, and three from the Caſpian ſea. The ground is rocky, but has a ſhallow covering of earth. If this be any where ſcraped off, and fire applied to the place, it catches fire immediately, and burns without diminution, nor ever goes out, unleſs you throw cold earth over it, by which it is eaſily extinguiſhed. A piece of ground, about two Engliſh miles in extent, has this wonderful property. In many parts of it there is a continual flame: the chief is in a hole about four feet deep and fourteen in diameter. This is ſaid to have burned many thouſand years. They burn ſtones into lime, by filling a hole in the ground with them, and then putting a lighted candle into

into the hole. The fire immediately kindles, and in about three days burns the ſtones ſufficiently.

It is remarkable, that this flame, how great ſo ever it be, gives neither ſmoke nor ſmell. There is much naphtha all about the place, though not juſt where the fire is.

Doubtleſs an inflammable vapour iſſues in abundance out of the ground in this place. Something of the ſame kind is found between Bologna and Florence, on the ſide of one of the Apennines. On a ſpot of ground three or four miles diameter, there is a conſtant eruption of fire. The flame riſes very high; yet without noiſe, ſmoke, or ſmell. In great rains it ſometimes intermits, but afterwards burns with the greater vigour. There are three other ſuch fires on the ſame mountains. Probably they riſe from the veins of bitumen.

20. A late ingenious writer aſcribes all earthquakes to the ſame cauſe, electricity. The impreſſion, ſays he, they make on land and water, to the greateſt diſtance, is inſtantaneous. This can only be effected by electricity. In the late earthquake the concuſſion was felt through the ſpace of a hundred miles in length, and forty in breadth, at the ſame inſtant. Now what could throw a tract of land, of four thouſand ſquare miles in ſurface, into ſuch an agitation in a moment? No natural power is equal to this, but that of electricity, which alone acknowledges no bounds, neither any ſenſible tranſition of time.

The little damage done by moſt earthquakes, is another argument, for their being occaſioned, by a ſimple vibration of the earth, through an electric ſhock. This vibration on the water, meeting with the ſolid bottoms of ſhips, occaſions that thump which is felt by them. That this ſhakes millions of ordinary houſes, and yet not one of them falls, is a farther proof, that it is not a convulſion in the bowels of the earth, but an uniform vibration, like what we occaſion in a glaſs, by rubbing our finger on the edge: which may be brought to ſuch a pitch, as to break the glaſs in pieces, by an electric repulſion of its parts.

There can be little doubt, but ſome earthquakes are owing

owing to electricity: but many more are owing to other cauſes: thoſe of Callao, Lima, Port-Royal, for inſtance, were unqueſtionably owing to water: thoſe in the neighbourhood of Ætna and Veſuvius, with thoſe in the Eaſt-Indies, to lakes of fire. The grand fault is therefore the aſcribing them either to electricity, or any one cauſe, excluſive of the reſt: whereas ſome are owing to each of theſe cauſes: ſome to ſeveral of them acting conjointly.

21. We have inflammable vapours in England, in three or four different places.

One who accurately obſerved it, gives the following particular account of a burning well.

" In the latter end of February, I went to ſee a ſpring in the road, which leads from Wigan to Warrington. When we came to it, and applied a lighted candle to the ſurface of the water, there was ſuddenly a large and vigorous flame produced. But having filled a cup with water at the flaming place, and having held a lighted candle to it, it went out. Yet the water at that place boiled like water over a fire: though when I put my hand into it, it did not feel ſo much as warm. This boiling ſeems to proceed from the ſulphureous fumes, the ſpring being not above forty yards from a coal-pit, and all the country for many miles round being under-laid with coal.

When the water was drained away, I applied the candle to the ſurface of the earth where the water burned before. The fumes took fire and burnt very bright and vigorous, the flame aſcending a foot and a half from the ground: and the baſis of it was as broad as a man's hat at the brim. It was not diſcoloured like that of ſulphur, nor had any ſcent. I ordered a bucket of water to be poured on the fire, and it was immediately quenched."

22. There was a ſpring of the ſame kind at Broſely, near Wenlock, in the county of Salop. It was diſcovered in June, 1711, by a terrible noiſe in the night, which awaked ſeveral people in their beds, who deſiring to know what it was, roſe up, and coming to a boggy place under a little hill about two hundred yards

from the Severn, perceived a mighty rumbling and ſhaking of the earth, and a little water boiling up through the graſs. When they dug up ſome of the earth, the water flew up to a great height, and a candle that was in their hand, ſet the vapour on fire. There is now (viz. in 1711) an iron ciſtern round the ſpring, with a cover, having a hole in the middle of it. If you put a lighted candle to the hole, the water takes fire, and burns like ſpirits of wine. It burns as long as you keep the air from it; but if you take up the cover, it goes out. The heat of this fire exceeds that of common fire. Some people, after they have ſet the water on fire, have put a kettle of water over the ciſtern, with a joint of meat in it. It was boiled much ſooner than it could be, by any artificial fire. If you put wood or even green boughs upon it, is preſently conſumes them to aſhes. The water of itſelf feels as cold as any common water. Nay, if you put your hand into it as ſoon as the fire is out, it feels as cold as if there had been no fire near it. But it ſtill continues boiling up, with a conſiderable noiſe.

But this well was loſt for many years. The poor man in whoſe land it was, miſſing the profit he uſed to have by ſhewing it, uſed all his endeavours to find it again: and in May, 1744, hearing a rumbling noiſe under ground, a little nearer the river than the former well was, he lighted upon it again. For five or ſix feet deep, it was above ſix feet wide. Within this was a ſmaller hole, of like depth, dug in the clay, in the bottom of which was a cylindric earthen veſſel, four or five inches diameter, having the bottom taken off, and the ſides fixed in the clay. Within the pot was brown water, thick as puddle, continually forced up with a violent motion and a hollow noiſe, riſing and falling by turns, five or ſix inches. Upon putting a candle at the end of a ſtick, within a quarter of a yard, it took fire, darting and flaſhing in a violent manner, about half a yard high, much like ſpirits in a lamp, but with a greater agitation. The man ſaid it had made a tea-kettle boil in nine minutes, and that it would burn forty-eight hours without any ſenſible diminution. It was extinguiſhed by putting a wet mop upon it. And ſtill the water felt very cold.

The

The well lay about thirty yards from the Severn, which in that place, and for ſome miles above and below, runs in a vale full a hundred yards perpendicular below the level of the country on either ſide. But the well is now loſt again, the water being drawn off by a coal-pit.

23. There is a fire of the ſame kind at Pietra Mala, a village on the Apennines. The flame is extremely bright, covers a ſurface of three yards by two, and uſually riſes about four feet. After great rains or ſnows, the whole bare patch, about nine yards diameter, flames. The gravel out of which it riſes, at a very little depth, is quite cold. There are four of theſe fires in the neighbourhood: the middle of the ground whence one of them riſes, is a little hollowed, and has in it a puddle of water, through which there are ſtrong ebullitions of air. This air will not take fire; but that which riſes through the wet and cold gravel, flames briſkly.

In Dauphiny, and ſome other parts of France the ſurface of ſeveral ſprings take fire in the ſame manner on the approach of a candle. Sulphureous vapours undoubtedly exhale from the waters: as is the caſe in the famous grotto del Cani.

This lies on the ſide of a little hill, between Naples and Pozzoli. The ſides of it are cut perpendicular in the earth. It is about three feet wide; near twelve feet long; five or ſix feet high at the entrance, and leſs than three at the farther end.

The ground ſlopes a little from this end to the mouth, and more from thence to the road. If you ſtand a few ſteps without, and ſtoop ſo as to have your eye nearly on a level with the ground of the grotto, you may ſee a vapour within, like that which appears over a chafing-diſh of red-hot coals, only that it is more ſluggiſh, and does not riſe above five or ſix inches high. Its ſurface more diſtinctly terminated than that of other vapours, balances viſibly under the air, as if unwilling to mix with it.

The ground of the grotto is always moiſt; and ſo are the ſides to the height of ten inches. Yet this never

ver increaſes ſo as to form any drops. While you ſtand upright, you remark nothing more, than a ſlight earthy ſmell, common in all ſubterraneous places which are kept ſhut. But if you put down your hand, within ten inches of the ground, it feels as if you put it into the ſteam of boiling water. Yet your hand contracts neither ſmell nor taſte. A vapour ſimilar to that in the grotto, riſes alſo from the ground without. But it is weaker, and does not riſe ſo high. This partly ſpreads itſelf from the cavern, partly exhales from the earth.

A lighted flambeau thruſt into the vapour, preſently goes out; yet without any noiſe or hiſſing. The thick ſmoke which appears immediately after its extinction, remains floating on the vapour, and being lighter than it, but heavier than the air above it, ſpreads between both. Indeed common ſmoke is lighter than air: but that impregnated with the vapour is heavier.

If a young vigorous dog be held down within the vapour, he at firſt ſtruggles, pants, ſnorts, and rattles in the throat. But in three minutes he lies as dead. Carry him into the open air, and he draws in long draughts, as one recovering from a fit, and in two minutes gets upon his legs, and ſeems to ail nothing. A cock having his head plunged into the vapour, was ſuffocated all at once beyond recovery. Frogs are ſtupified by it in three or four minutes: yet though they have laid in it a quarter of an hour, ſoon recover when placed in the open air. Large flies, beetles and butterflies, were longer without giving ſigns of their ſuffering, and longer in recovering. A toad reſiſted the vapour near half an hour, a lizard above an hour and a quarter. And a large graſshopper ſtirred in the vapour, after being more than two hours in it.

An Engliſh gentleman kneeled down in the grotto, and leaning on his hands, bowed his face to within two or three inches of the ground, holding his breath, keeping his eyes open, and his tongue a little out of his mouth. He remained thus three or four ſeconds, without any painful impreſſion, or any ſort of taſte on his tongue. And hence it manifeſtly appeared, that this is not a poiſonous vapour.

He

He afterward advanced his face to the ſurface of the vapour, and took in breath gently. He was ſenſible of ſomething ſuffocating, juſt like the air of a hot and moiſt ſtove. Likewiſe he felt a ſlight acrimony in the throat and noſe, which made him cough and ſneeze: but no head-ach, no ſickneſs at ſtomach, nor any other inconvenience.

It is clear then upon the whole, that animals die in this vapour, not as poiſoned, but rather as drowned, in a fluid not capable of ſupplying the place of the air, which is neceſſary for reſpiration, and equally neceſſary to ſuſtain fire, as the flame of a lighted flambeau.

24. A fire of a ſtrange nature appeared in Wales, about Chriſtmas, 1693. A fiery vapour came from the ſea, and moved up and down for many weeks. It ſet on fire ſixteen ricks of hay, at Harlech, in Merionethſhire, and two barns, and annoyed the country, as well by poiſoning the graſs, as firing the hay. It was a blue, weak flame, and did no harm to the men who tried to ſave the hay, though they ventured even to touch it. An intelligent perſon who lived near Harlech, informed his friend ſome time after, "The fire ſtill continues there. It covers over a part of the ſea, from a marſhy place in Carnarvonſhire, eight or nine miles off. The graſs over which it moves kills all manner of cattle that feed upon it, ſheep, goats, ſwine, cows and horſes. But what is very remarkable is, that any great noiſe, as beating a drum or ſounding a horn, effectually repels it from any houſe, or barn, or ſtack of hay."

25. A much ſtranger flame than that which iſſues out of the earth, is that which iſſues out of the ſtomach of animals. The anatomical lecturer at Piſa, in the year 1597, happening to hold a lighted candle near the ſubject he was diſſecting, on a ſudden ſet on fire the vapours that came out of the ſtomach he had juſt opened. In the ſame year, as Dr. Ruiſch, then anatomy profeſſor at Piſa, was diſſecting a woman, a ſtudent lighting him with a candle, he had no ſooner opened

opened the ſtomach, than there iſſued out a yellow greeniſh flame. A like thing happened ſome years after at Lyons, in diſſecting a woman. Her ſtomach was no ſooner opened, than a conſiderable flame burſt out and filled the place. But this is not ſo much to be wondered at, ſince the experiments made by Dr. Vulpari, anatomical profeſſor at Bologna. He affirms, any one may ſee, iſſuing from the ſtomach of an animal, a matter that burns like ſpirits of wine, if the upper and lower orifices are bound faſt with a very ſtrong thread. The ſtomach thus tied muſt be cut, above and under the ligature, and afterwards preſſed with both hands, ſo as to make all that it contains, paſs to one ſide. This will produce a ſwelling in that part, which muſt be held with the left hand to hinder its eſcaping. A candle then being held about half an inch from the ſtomach, let it be ſuddenly opened by the right hand, and a bluiſh flame will immediately guſh out, which will ſometimes laſt a minute. The ſame way flame may be brought forth from the inteſtines alſo.

Nor is it from carcaſes only that flames have iſſued. This has been the caſe with live perſons likewiſe. Bartholine relates, that a Popiſh Cavalier, having drank a quantity of brandy died in a little ſpace, after an eruption of a flame through his mouth. He relates alſo the caſe of three others, who after drinking much brandy experienced the ſame ſymptom. Two preſently died; the third eſcaped by immediately drinking cold water. Still more aſtoniſhing is the caſe of a woman at Paris, who uſed to drink brandy to exceſs. She was one night reduced to aſhes by a fire from within, all but her head, and the ends of her fingers. In like manner Cornelia Bandi, an aged lady of unblemiſhed life, near Ceſena in Romagna, in 1731, retired in the evening into her chamber; and in the morning was found in the middle of the room, reduced to aſhes, all except her face, ſcull, three fingers and her legs, which remained entire, with her ſhoes and ſtockings. The aſhes were light: the floor was ſmeared with a groſs, ſtinking moiſture, and the walls and furniture covered with a moiſt ſoot, which had ſtained all the linen in the cheſt.

Perhaps

Perhaps a larger account of ſo remarkable an incident will not be unacceptable to the curious reader.

The Counteſs of Cornelia Bandi, in the ſixty-ſecond year of her age, was all day as well as uſual. When ſhe was in bed, ſhe paſſed two or three hours in talking with her maid; then ſhe fell aſleep. The maid going into her chamber into the morning, ſaw two feet diſtant from the bed, a heap of aſhes, and two legs with the ſtockings on. Between them was part of the head; but the brains, half the ſcull, and the whole chin were burnt to aſhes. The aſhes when taken up, left in the hand a greaſy and ſtinking moiſture. The bed received no damage; the clothes were raiſed on one ſide, as by a perſon riſing from it.

Doubtleſs the fire was kindled within her by the juices and fermentations in the ſtomach, acting on the many combuſtible matters, which abound in living bodies, for the uſes of life. Theſe in ſleep, by a full reſpiration, are put into a ſtronger motion, and conſequently are more apt to take fire.

Borelli obſerves, that ſuch accidents often happened to great drinkers of wine and brandy. Such flames would frequently riſe in us, if the natural moiſture did not prevent.

Undoubtedly ſhe was burnt ſtanding; hence her ſcull was fallen between her legs, and the back part of her head was damaged more than the fore part, partly becauſe of her hair, partly becauſe in the face, there were many places out of which the flames might paſs.

An inſtance of the ſame kind occurred at Chriſt Church in Hampſhire, on June 26, 1613. One John Hitchell, a carpenter of that pariſh, having ended his day's work, came home and went to reſt with his wife. Her mother being frightened in her ſleep, called to them for help. None anſwering, ſhe ſtarted up and waked her daughter, who found her huſband dead by her ſide. She dragged him out of the bed into the ſtreet; but the heat then forced her to let him go. He lay burning there for three days. Not that there was any appearance of fire outwardly, but only a ſmoke aſcending from his carcaſe, till it was burnt to aſhes: except only a ſmall part of his bones which were caſt into a pit.

Grace

Grace Pett, was a fiſherman's wife, of the pariſh of St. Clement's, in Ipſwich, about ſixty. She had a cuſtom for ſeveral years of going down ſtairs every night, after ſhe was undreſt, to ſmoke a pipe. Her daughter who lay with her, did not miſs her till the morning, April 10, 1744, when going down ſtairs ſhe found her mother's body extended over the hearth, with her legs on the deal floor, and appeared like a block of wood, burning with a glowing fire without flame. The neighbours coming in at her cries, found the trunk of the body in a manner burnt to aſhes. It then appeared like a heap of charcoal, covered with white aſhes, the head, arms, legs, and thighs, were alſo much burnt. A child's clothes, on one ſide of her, and a paper-ſkreen on the other, were untouched. The deal floor alſo on which her legs lay, was neither ſinged nor diſcoloured.

26. Almoſt as ſtrange, though not attended with any ill conſequence, was the following incident. In November, Mrs. Suſanna Sewall, wife to Major Sewall, in New England, obſerved a ſtrange flaſhing of ſparks in all the apparel ſhe put off, which continued till candlemas. In the company of many perſons, ſhe ſent for ſeveral parts of her wearing apparel, and when they were ſhaken, ſparks flew out, making a noiſe, much like bay-leaves thrown into the fire. One ſpark lit on major Sewall's thumb-nail, without any heat, and continued at leaſt a minute before it went out. They cauſed Mrs. Sewall one day to put on her ſiſter Digge's petticoat; and when ſhe put it off at night, it ſparkled as her own uſed to do.

27. There is no body but may be by fire converted into glaſs; not excepting gold itſelf. And this is the laſt effect of fire: no art can carry the change of a natural body any farther.

As to the nature and properties of it. 1. Common glaſs is an artificial compound of ſalt with ſand or ſtones. 2. It is fuſible by a ſtrong fire, and when fuſed is tenacious and coherent. 3. It does not waſte in the fire. 4. When melted it cleaves to iron. 5. When red hot it is faſhionable into any ſhape, and capable

pable of being blown into a hollowneſs, which no mineral is. 6. It is frangible when thin, fryable when cold, and tranſparent whether hot or cold. 7. It is flexible, elaſtic, and diſſoluble by cold. It can be cut only by emery or a diamond. 8. It is not diſſoluble by Aquafortis, Aqua Regia, or Mercury. 9. Neither acids nor any thing elſe extract colour, taſte, or any ſenſible quality from it. 10. It looſes nothing either of its ſubſtance or of its weight, by the longeſt and moſt frequent uſe. 11. It is not capable of being calcined, neither of contracting ruſt.

But there is no property of glaſs more remarkable than its ductility. Glaſs-ſpinners draw threads of their brittle matter, melting over a lamp, with far more eaſe and expedition, than common ſpinners do thoſe of flax or ſilk. Theſe may be drawn fine as a hair, yea, as the thread of a ſpider's web, ſo as to wave with every wind. And the finer they are, the more flexible. If the ends of two ſuch threads be knotted together, they may be drawn and bent till the ſpace in the middle of the knot does not exceed the forty-eighth part of an inch in diameter.

Near the bay of Acre, in Paleſtine, runs a little river, now called Kardanah, ſuppoſed to be the ancient Belus, famous for its ſand, much uſed in making glaſs, and ſaid to have given riſe to the invention of it. The Sidonians are reported to have made this diſcovery, from the following accident. Some travellers having reared an hearth on the ſand of this river with large pieces of nitre, and ſet ſome fern on fire under a kettle, in order to boil their victuals, perceived the ſand and the nitre to melt and incorporate with the fern-aſhes, and preſently after run in a tranſparent ſtream, which hardened as it cooled. From hence the hint of making glaſs was taken, which was gradually improved to its preſent uſe and beauty.

28. There are few phænomena relative to glaſs more hard to be accounted for, than that of the Bologna bottle, ſo called, becauſe it was firſt diſcovered at Bologna. If you let theſe bottles fall from ſome height on a brick-floor, they will not be broken; but drop into them ſome hard body, and they will burſt in pieces.

I took

I took one of theſe, ſays Dr. I. which held near a pint, and let it fall five feet and a half on a brick floor, and it was not broken. I dropt into it a bit of flint, weighing eleven grains, and immediately it burſt in pieces.

I dropt into another bottle a ball of lead, weighing one hundred and forty grains, into a third a piece of braſs weighing three hundred grains, and neither of them was broken.

Theſe glaſſes only differ from common phials in this, they have not cooled gradually in what is called, the nealing furnace, but are expoſed to the open air as ſoon as formed. They reſiſt hard blows from without. I have given to ſome, violent ſtrokes with a mallet, and they have not broke. They likewiſe do not break, though ſeveral heavy bodies be dropt into them. I have dropped into them from the height of three feet, muſket-balls, and pieces of iron, braſs, gold, without any effect; but when I dropt into it from the height of three inches, a ſhiver of flint no bigger than a ſmall pea, in about two ſeconds the glaſs flew. Having tried the experiment on ſeveral others with the ſame piece of flint, moſt of them broke in the moment of the ſtroke, the reſt one or two ſeconds after it.

I let fall into ſeveral glaſſes a flint of half the ſize, and they flew in like manner. I let fall into one, a flint no larger than a grain of ſand, ſhook the glaſs, and ſet it down. I did the ſame with four others. In about half an hour one of them flew, and the other four ſoon after.

I let fall into one a ſapphire ſet in a ring: and though the bottom of the glaſs was near an inch thick, the ſapphire paſſed through it as through a ſpider's web. The glaſs flew all ways, and the ring remained on the table, juſt where it fell.

A bit of china, half a line thick and two lines broad, broke ſeveral glaſſes, ſo did a bit of glaſs of the ſame ſize: ſo did diamonds alſo. And a very ſmall piece of tempered ſteel, broke all the glaſſes into which I dropped it.

Some large hollow cups made at Worceſter of common green glaſs, much larger than the others, and ſome of them above three inches thick at the bottom, though they were not affected by a muſket-ball, dropt

from

from the height of near three feet, were inſtantly broken with a ſhiver of flint, weighing but two grains.

There is ſomething aſtoniſhing in the power of Teleſcopes, to bring far diſtant objects near; and of Microſcopes, to render thoſe clear and diſtinct, which are quite inviſible to the naked eye. And no leſs amazing in another kind, is the force of burning glaſſes. 1. A piece of wood laid before a large burning-glaſs, took fire in an inſtant. 2. Water contained in an earthen veſſel boiled immediately, and in a ſhort time quite evaporated. 3. A maſs of lead, three inches thick, began to melt in a moment, and ſoon after ran in a continued thread. 4. A ſteel-plate grew red-hot almoſt in an inſtant, and ſmall holes were made through it. 5. Slate becomes black glaſs; tiles, yellow glaſs; earthen pots, a darkiſh yellow glaſs. 6. A pumice ſtone became white glaſs; earth, black glaſs; bones an opaque one.

But in the extremely hot weather at Paris in 1703, the rays of the ſun, collected by a large glaſs, had ſcarce any force, though the ſeparate rays quite inflamed the air. The reaſon of ſo ſurpriſing a thing ſeems to be, that the heat raiſed from the earth's great ſulphureous exhalations, embarraſſed, ſtopped, and in ſome degree abſorbed the rays of the ſun.

29. Equally ſtrange are the phænomena of the Glaſs-drop. The make of this drop is as ſimple, as its explanation is difficult. They take up a ſmall quantity of melted glaſs on the top of an iron rod, and let it drop into a pale of water. When it does not break in the operation, it forms the glaſs-drop. This is of ſuch firmneſs, that it bears ſmart blows of a hammer, without breaking. But if you break only the tip of the ſmall end, the whole ſhatters into powder. This ſhattering is attended with a loud report, and the powder ſcatters all around. If the experiment be made in the air-pump, the drop burſts more impetuouſly, and the duſt is finer than when it burſts in the open air. This is a plain matter of fact. I do not undertake to account for it.

Gunpowder is commonly ſuppoſed to have been invented by Barthold Schwartz, about the year 1380.

But

But Roger Bacon knew of it, a hundred and fifty years before Schwartz was born. For in his treatiſe de Nullitate Magica, publiſhed at Oxford in 1216, are theſe words. "You may raiſe thunder and lightning at pleaſure, by only taking ſulphur, nitre, and charcoal, which ſingle have no effect, but mixed together and confined in a cloſe place, cauſe a noiſe and exploſion greater than that of a clap of thunder."

The effect of gunpowder is owing to the ſpring of the air, incloſed in the grains and in the ſpaces between them. All theſe ſprings are dilated by the fire, and ſet a playing at once. The powder itſelf only ſerves to light the fire, which puts the air in action.

Aurum fulminans, a preparation of gold, is far ſtronger than gunpowder. A ſcruple of this acts more forcibly than half a pound of that. A ſingle grain laid on a knife, and lighted at a candle, goes off with a greater noiſe than a muſket.

30. Air is that clear, tranſparent, compreſſible fluid which is extended at leaſt round the terraqueous globe, being with us about 46,656,000,000 times more denſe and ſluggiſh than æther, betwixt which and the air there is a very great affinity or attractive force, which is as their denſity; i. e. the air contiguous to the æther takes in and concentrates the æther proportionally to its greater denſity, by which it is rendered more ſpringy and active, with this difference, that the air by contact and coheſion in the parts of bodies, becomes ſolid and unelaſtic (but æther never); from whence again, by heat, fire, or diſſolution of parts being ſeparated, its elaſticity returns. This element has a near affinity or relation to water, becauſe it eagerly takes up rarefied water into itſelf, as water again drinks up a portion of air within its contact; ſo that air and water actuated by æther, make the levers and wedges by which nature performs all her changes in bodies. And it ſerves as the common medium of communication between us and all bodies.

The preſſure of a column of air upon a ſquare inch only, is equal to fifteen pounds weight. That upon the ſurface of a human body, generally amounts to at leaſt thirteen tons weight: ſeeing all fluids preſs with

an

an equal force every way, upwards, downwards, ſideways, and in all directions.

" But how is it then that our bodies are not cruſhed in pieces ?" Our bodies, as well as all others, are filled with air throughout: and the ſpring of the internal air is equal to the preſſure of that without. And when two equal forces act in contrary directions, they entirely deſtroy each other's effects: hence, if the ambient air preſs upon us, it is all one as if it did not preſs at all.

The elaſticity of the air is a counterbalance to its gravitation. And how neceſſary is it, that theſe ſhould balance each other? Were the power of gravity to be ſuſpended for a moment, and that of elaſticity to remain, the atmoſphere would inſtantly be diſſipated, through the infinite regions of ſpace. But while the weight of the air and its elaſtic force are equal, they produce an equilibrium among the particles of air, in every part of the atmoſphere.

As the higher it is, the air is more and more expanded, gravitation being leſs and leſs, ſo the parts of the air in the upper regions will be expanded only not to infinity.

The air is generally inviſible. And it is neceſſary it ſhould be ſo. For as it is the medium through which we ſee objects, if the parts of it were perceptible, it would render the view of theſe objects far leſs perfect and diſtinct. Hence a greatly magnifying teleſcope, as it ſhews the body of air, makes the view of other objects more confuſed.

Yet in ſome caſes you may ſeem to ſee the air. In a very hot ſummer's day, in an open part of the country, place yourſelf on an eminence, nearly facing the ſun. Then, if there be a gentle wind, there will be a reflexion of light from the body of the air in the vale below. And you will ſee the undulations or waves of air almoſt as perfectly as you may thoſe of water, agitated by a gentle wind. And yet in truth, it is not the air which you ſee, but the vapours that float therein.

One property of air is its weight or gravity. This you will immediately feel, if you lay your hand on the mouth of a veſſel, which is emptied of air. If you lay a ſquare piece of glaſs on the orifice of an air-

pump,

pump, when the air is drawn out, it will be broke to ſhivers with a great noiſe. Or extract the air from between two ſmoothly poliſhed marbles, and cloſe the edges with wax, they will then be ſo ſtrongly preſt together, as not eaſily to be ſeparated. But we need no other proof of it than the barometer: a glaſs tube, cloſe at one end, and filled with mercury. Immerge the other end in a baſon of the ſame fluid, and when it is erected, the mercury in the tube will riſe thirty inches, above the ſurface of that in the baſon.

The changes then in the barometer are wholly owing to the changes in the weight of the atmoſphere. But to what are theſe owing? It ſeems, chiefly to the winds. For 1. Theſe muſt alter the weight of the air in any particular place, either by bringing together and accumulating the air, which is the caſe when two winds blow at the ſame time from oppoſite points: or by ſweeping away part of the air, as when two winds blow oppoſite ways from the ſame point: or laſtly, by cutting off the preſſure of the atmoſphere, which happens when any wind blows briſkly any way: 2. Cold, nitrous particles load the atmoſphere, and increaſe its weight: 3. So do heavy, dry exhalations from the earth: 4. The air being rendered heavier is more able to ſupport the vapours, which being intermixed with it, make the weather fair and ſerene. When it is rendered lighter by the contrary cauſes, it becomes unable to ſupport the vapours, which then ſink, gather into drops, and fall in rain.

With us the mercury is the higheſt when the wind is north or north-eaſt, and ſo brings the cold, condenſed air of the northern climates. In all northern countries the mercury varies more than in the ſouthern, the winds being more frequent, ſtrong, various and oppoſite to each other. Between the tropics it ſcarce varies at all, the winds being ſmall, and generally blowing the ſame way.

The preſſure of the air, is, cæteris paribus, as its height. Carry the barometer to a higher place, where the incumbent column of air is ſhorter, and a ſhorter column of air is ſuſtained: it being found to deſcend at the rate of a quarter of an inch for every hundred feet of aſcent.

Now air, as all other fluids, muſt preſs equally every way. Hence it is, that ſoft bodies ſuſtain their preſſure, without any change of figure, and brittle bodies without breaking, though that preſſure be equal to that of a column of mercury, thirty inches high, or a column of water of thirty feet. Nothing can keep theſe bodies unchanged, but the equable preſſure on all ſides, which reſiſts as much as it is reſiſted. And hence on removing or leſſening that preſſure on one ſide, the effect of it is ſoon perceived on the other.

It is by means of its gravity, 1. That the air cloſely inveſts the earth with all the bodies on it, and bends them down: that it prevents the arterial veſſels of plants and animals from being too much diſtended, by the impetus of the circulating juices: and that it hinders the blood from oozing out, through the pores of their containing veſſels. Hence they who travel up high mountains, the higher they aſcend, are relaxed the more, till they fall into ſpitting of blood. 2. The mixture of contiguous fluids is chiefly owing to this. Hence many fluids which readily mix in the air, when that is removed, remain ſeparate. 3. It determines the action of one body upon another. Thus it preſſes the particles of fire againſt the fuel. Whereas upon removing the air, the fire immediately goes out. So aqua regia ceaſes to diſſolve gold, if the air be taken away: hence alſo on the tops of high mountains, as on the Pike of Teneriffe, the moſt acrid bodies, ſuch as pepper, ginger, ſalt, have no ſenſible taſte; for want of a ſufficient gravity in the air to preſs their particles into the pores of the tongue.

Another property of air is elaſticity. It yields to an impreſſion, by contracting its dimenſions, and returns to them, on removing the impreſſive cauſe. This endeavour to expand itſelf, every particle of air continually exerts, againſt an equal endeavour of the ambient particles. Hence it is, that a bladder full of air, will burſt in an exhauſted receiver: while one that before ſeemed empty, ſwells and appears to be full of air.

This power does not ſeem to have any bounds. Nor is it eaſy to be deſtroyed. Let air be expanded ever ſo much, it ſtill retains its ſpring. Nor is this ſenſibly

diminiſhed

diminiſhed by any experiment which has yet been made.

There is no fixing any bounds to its condenſation, any more than to its dilatation. It will dilate into a thouſand times its former ſpace, yea into 13,679 times. And all this by its own expanſive force, without any force of fire. The air we breathe near the ſurface of the earth is compreſt by its own weight, into at leaſt the 13,679th part of the ſpace it would poſſeſs in vacuo. And if the ſame air be farther condenſed by art, the ſpace it will take up when moſt dilated, will be (according to Mr. Boyle) to that it poſſeſſed when moſt condenſed, as 550,000 to one.

If while we increaſe the elaſticity of air, on one ſide by compreſſion, we increaſe it on the other ſide by heat, the force of both ſoon becomes irreſiſtible; and a French philoſopher ſuppoſed, that air thus confined and expanding was ſufficient for the exploſion of a world. In order to determine the elaſticity of air, the wind-gun has been invented, which is an inſtrument that compreſſes a large quantity of air into a tube in which there is an ivory ball, and then gives the compreſſed elaſtic air free power to act and drive the ball as directed. The ball thus driven will pierce a thick board, and will be as fatal at ſmall diſtances, as if driven with gun-powder. I do not know whether ever the force of this inſtrument has been aſſiſted by heat; certain I am, that this, which could be very eaſily contrived by means of phoſphorus, or any other hot ſubſtance applied to the barrel, would give ſuch a force as I doubt whether gun-powder itſelf could produce.

Every thing we ſee gives of its parts to the air, and has a little floating atmoſphere of its own round it. The roſe is encompaſſed with a ſphere of its own odorous particles; while the night-ſhade infects the air with ſcents of a more ungrateful nature. The perfume of muſk flies off in ſuch abundance, that the quantity remaining becomes ſenſibly lighter. A thouſand ſubſtances that eſcape all our ſenſes, we know to be there; the powerful emanations of the loadſtone, the effluvia of electricity, the rays of light, and the inſinuation of fire.

fire. Such are the various ſubſtances through which we move, and which we are conſtantly taking in at every pore, and returning again with an imperceptible diſcharge.

This great mixture of all earthly bodies is continually operating upon itſelf; which perhaps, may be the cauſe of its unceaſing motion; but it operates ſtill more viſibly upon ſuch groſſer ſubſtances, as are expoſed to its influence; for ſcarce any ſubſtance is found capable of reſiſting the corroding qualities of the air. The air, ſay the chymiſts, is a chaos furniſhed with all kinds of ſalts and menſtruums; and therefore it is capable of diſſolving all kinds of bodies. It is well known that copper and iron are quickly eaten with ruſt: and that in the climates near the equator no art can keep them clean. In thoſe countries, inſtruments, knives, and keys, though kept in the pocket, nevertheleſs are quickly incruſted; and the great guns, with every precaution, after ſome years become uſeleſs. Stones may be ſuppoſed to be more eaſily ſoluble. The marble of which the noble monuments of Italian antiquity are compoſed, although in one of the fineſt climates in the world, nevertheleſs ſhew the impreſſions which have been made upon them by the air. In many places they ſeem worm-eaten by time; and in others, they appear crumbling into duſt. Gold alone ſeems to be exempted from this general diſſolution. It is never found to contract ruſt, tho' expoſed never ſo long: the reaſon is, that ſea-ſalt, which is the only menſtruum of gold, is but very little mixed with the air, being a very fixed body, and not apt to volatilize. In the laboratories however, where the air is impregnated with it, gold is found to ruſt, as well as other metals.

By its elaſticity air inſinuates into the pores of bodies, carrying with it this faculty of expanſion; whence it muſt neceſſarily put all the particles it is mixed with, into perpetual oſcillations. And as its elaſticity is never the ſame for two moments together, there muſt be an inceſſant dilatation and contraction in all bodies. To this is owing all putrefaction and fermentation, neither of which will proceed in vacuo. And indeed all natural corruption and alteration ſeem to depend hereon: ſo that metals, particularly gold, are ſo durable,

only by being impervious to air. And yet it may be doubted, whether air itſelf be the true, original, univerſal diſſolvent; or rather the ethereal fire, which is intimately united with every particle of it: and without which air is effete and uſeleſs, neither able to feed flame, nor to ſuſtain animal life.

That there is ſome matter in air much finer than the air itſelf, appears from many conſiderations. In an exhauſted receiver ſomething remains, which conveys the heat, near as readily as air. Now this muſt be a body, and a body ſubtle enough to penetrate the pores of glaſs. Doubtleſs then it penetrates the pores of all other bodies, and conſequently is diffuſed through the univerſe. And this ſeems to be not only more ſubtle than the air, but far more weighty and elaſtic. To the weight of this may be owing the weight of the air, and of all other bodies: to its elaſticity, the elaſticity of the air, and of all other elaſtic bodies. This alſo may cauſe the reflection and other phænomena of light: as alſo ſenſation, and muſcular motion. Indeed it ſeems to be the firſt ſpring of all the action in the univerſe.

Air is ſometimes deprived of its elaſticity, and wrought into the ſubſtance of other bodies, from which nevertheleſs it may be extracted, and reſume its elaſtic ſtate. As to animal ſubſtances, a very conſiderable quantity of air is extracted from them by diſtillation, not only from the blood and fat, but alſo from the moſt ſolid parts of animals. Half a cubic inch of a fallow deer's horn, produced 117 cubic inches of air; half a cubic inch of oyſter ſhells, no leſs than 162 cubic inches.

As to vegetable ſubſtances, half a cubic inch of heart of oak generated 108 cubic inches; a cubic inch of peas, 396 cubic inches, or 113 grains, which was above a third of its weight. This air will flaſh, if touched with a candle.

Camphire generates no air: brandy next to none: well-water, or rain-water, a little: Pyrmont-water, twice as much; which air contributes to the briſkneſs of this and other mineral waters.

From minerals much air may be extracted. Half an inch of Newcaſtle coal yielded 180 inches of air, which weighed near one third of the coal.

Yet

Yet a good part of the air extracted from theſe bodies, in ſome days gradually loſt its elaſticity: becauſe the acid, ſulphureous fumes, raiſed with the air, reſorbed and fixed the elaſtic particles. But when a means was found, to prevent this, it loſt only a ſeventeenth or eighteenth part: and that chiefly in the firſt twenty-four hours; the reſt was permanently elaſtic.

There is another way of producing air, which ſeems to be more natural, namely by fermentation. A cubic inch of * oil of vitriol with half an inch of ſal ammoniac generated ſix cubic inches of air: ſix inches of powdered oyſter-ſhells, and an equal quantity of white-wine vinegar, generated twenty-nine inches.

That much air is incorporated into the ſubſtance of vegetables, appears from the following experiments.

Forty-two inches of ale from the tun generated in three months, 636 cubic inches of air: twelve inches of Malaga raiſins, in ſix weeks generated 411 inches: twenty-ſix inches of apples, in thirteen days generated 968 inches of air. They then in three or four days reſorbed about twelve inches, and afterwards neither generated nor reſorbed.

That the air ariſing from diſtilled or fermenting bodies, is true air, appears from hence, that it continues in the ſame expanded ſtate for weeks, or months, which expanded vapours will not do. And that it is elaſtic appears, by its dilating and contracting with heat and cold, as common air does.

Air then makes a very conſiderable part of the ſubſtance of vegetables as well as animals. And beſide theſe particles of air which ſtrongly adhere to, and are wrought into their ſubſtance, there is in them a large quantity which is upon the wing, and in a very active ſtate.

To ſhew how much air is contained in white paper, take as many ſlips of it as weigh a hundred grains. Burn theſe warily by the flame of a candle, and then

* Mr. Geoffry ſhews, that the mixture of any vitriolic ſalts with inflammable ſubſtances, will yield common brimſtone: particularly of oil of vitriol with oil of turpentine. Brimſtone therefore is nothing but vitriolic ſalt, united with ſome combuſtible ſubſtance.

weigh the aſhes. You will find the hundred grains reduced to ſix. So ninety-four grains out of one hundred, are undeniably transformed into air. They could not be annihilated. And they could not riſe and fly away without a repelling force to carry them off. Thus the candle itſelf is by degrees transformed from heavy palpable wax, into a light, impalpable body of air. But obſerve: all bodies which thus become air, paſs through the intermediate ſtate of flame. So that properly ſpeaking, the ſame body was one moment paper, the ſecond moment fire, and the third, air. How different ſtates for the ſame ſort of matter to ſubſiſt in, in ſo ſhort a time.

The air-pump ſhews how much air is, even in water. Place a tall glaſs of water in the receiver. Turn the winch, and you ſee bubbles of air through the body of the water. Firſt they are thick, but ſmall; then they grow large, and riſe to the top of the water. And as long as the pump works, ſo long the air riſes, but more ſlowly, and in larger bubbles. In wine the air-bubbles ruſh violently to the top and burſt. Nay, and the liquor perfectly boils, like water on the fire. Yea, and hot water may be made to boil by the air-pump, as well as by fire. Hence it appears, that boiling is nothing but the motion produced from the expanſion of the air, whether by fire, or by the warmth and pump conjointly.

By another experiment it appears, that any piece of wood is pervious to the air, and that its air-veſſels run through the whole length or ſubſtance of the tree. Nay, quickſilver may be made to paſs through a piece of wood, and deſcend in the form of a ſhower of rain.

By the air-pump we likewiſe meaſure the weight, and find that a pint of it weighs 8 grains. Conſequently a gallon weighs a little more than a drachm: therefore a buſhel weighs an ounce and half a drachm.

Another experiment proves what one would not ſuſpect. Bodies moving in a fluid, meet ſo much the more reſiſtance, as their bulk is larger in equal weight. So a cork of equal weight with a guinea, meets with ſo much the more reſiſtance from the air. But in an exhauſted receiver, the largeſt bulk of cork, which was

before

before the moſt reſiſted, now proves the heavier body, and accordingly falls more ſwiftly than the gold.

Again. Strike a flint againſt the ſteel in vacuo, and it will occaſion no ſparks. So neceſſary is air to the very appearance of fire.

Air is generated likewiſe from minerals by fermentation. By other fermenting mixtures it is abſorbed again, and by others generated and abſorbed alternately.

A quarter of an inch of filings of iron, and an inch of compound aquafortis, in four days abſorbed 27 inches of air. When hot water was poured upon it, it generated three or four inches, which after ſome days it abſorbed again. A quarter of an inch of iron filings, with an inch of powdered brimſtone, abſorbed nineteen inches in two days. Powdered brimſtone mixed with Newcaſtle coal, neither generated nor abſorbed.

An inch of chalk, and as much oil of vitriol in three days generated 31 inches of air. Part of this it afterwards reſorbed. Two inches of lime and as much ſal ammoniac abſorbed 115 inches. The fumes of this are therefore very ſuffocating. All burning and flaming bodies, abſorb much air. And whereas the air which ſome ſubſtances abſorb, is afterwards remitted, that which is abſorbed by burning brimſtone, by the flame of a candle, or by human reſpiration, does not recover its elaſticity.

The elaſticity of the air in the veſicles of the lungs is continually decreaſing, through the vapour it is there loaded with: ſo that there needs freſh air continually; otherwiſe thoſe veſicles will ſoon fall flat, whereby the motion of the blood through the lungs being ſtopt, inſtant death enſues. And this ſeems to be exactly the caſe of moſt of thoſe who are killed by lightning, which ſo totally deſtroys the elaſtic air in the lungs, that they inſtantly fall flat.

31. Many have imagined that the animal fluids are furniſhed with air by the lungs only. But undoubtedly they are alſo ſupplied therewith, by way of the chyliferous canals: and that in no ſmall quantity. For the air, like all other animal fluids, requires to be perpetually

petually renewed; accordingly old particles fly off every moment, and new ones ſucceed in their place.

It may be demonſtrated, that urine contains much air. Doubtleſs ſo does the perſpirable matter: which being the lighteſt of all animal fluids, is the chief vehicle of the effete and uſeleſs air.

And that candles ſoon go out, if they are confined in a ſmall quantity of air, ſeems not to be ſo much owing to their having rendered the air effete, by conſuming its vivifying ſpirit, as to its deſtroying the elaſticity thereof by its acid, fuliginous vapours.

But nothing deſtroys the elaſticity of air like brimſtone, whether burning or in fermenting mixtures. And as the attractive power of bodies, is found to be more or leſs, as they have more or fewer ſulphureous particles, ſo we may reaſonably aſcribe the fixing the elaſtic particles of air, to the ſtrong attraction of the ſulphureous particles, with which Sir Iſaac Newton ſuppoſes all bodies to abound, more or leſs.

The various mixtures in the ſtomach, ſometimes generate, ſometimes abſorb air. In a good digeſtion the generating power exceeds the abſorbing power but a little. When it exceeds it much, we are troubled more or leſs, with diſtending flatus's.

We have ſeen how much air may be extracted from animal and vegetable bodies, into whoſe ſubſtances it was before intimately and firmly incorporated. And conſequently great quantities of air muſt be continually expended in their production. Part of this, we ſee, may reſume its elaſtic ſtate, when their texture is diſſolved; but part probably never regains its elaſticity, at leaſt, not in many centuries. However, we may ſee, what immenſe treaſures of this important element, the wiſe Author of nature has abundantly provided, the conſtant waſte of it being abundantly ſupplied, by heat or fermentation from innumerable denſe bodies.

If all the parts of nature were endued with a ſtrongly attracting power only, whole nature would immediately become one unactive, cohering lump. It was therefore abſolutely neceſſary there ſhould be every where intermixed, a due proportion of ſtrongly elaſtic particles. And ſince abundance of theſe are continually reduced from an elaſtic to a fixed ſtate, it was alſo neceſſary

ceſſary that theſe particles ſhould be endued with a property of reſuming their elaſticity, whenever they were diſengaged from that maſs, in which they were fixed. And hereby this beautiful frame of things, is maintained in a continual round, of the production, and diſſolution of animal and vegetable bodies.

The air is very inſtrumental in the production and growth of animals and vegetables: in its elaſtic ſtate, by invigorating their juices; and in its fixed ſtate, by greatly contributing to the union and firm connection of their conſtituent parts. It is alſo a very powerful agent in the diſſolution of the ſame bodies.

32. That fixed air is a cementing principle, appears (to omit others) from that well-known experiment: Quick lime diſſolves fleſh, by extracting and imbibing the fixed air, which it contained. But while the fleſh falls in pieces from the loſs of the principle, the lime grows ſolid by having it reſtored.

That it contributes alſo to the diſſolution of bodies appears hence. During the progreſs of putrefaction, a volatile matter flies continually from the putrefying ſubſtance. And this is no other than air, which is now extricated and thrown off from a fixed and unelaſtic ſtate, but immediately returns to it again, on meeting with a proper recipient.

The preſerving bodies, from putrefaction, depends almoſt in every inſtance, on reſtraining the flight of the fixed air. For as this cements their conſtituent parts, ſo putrefaction, which is the diſunion of them, cannot take place while this remains.

And this air both corrects, and prevents putrid acrimony in the animal fluid. Hence any food which does not contain a due proportion of it, is found to promote putrefaction: as do all damaged vegetables, which being incapable of fermentation, are incapable of producing the due quantity of air.

But pure air is no where to be found. That which ſurrounds us is the moſt heterogeneous body in nature. It is no other than an univerſal chaos, a colluvies of all kinds of bodies. No bodies can withſtand the force of fire. And whatever fire can volatilize is found in the air. Hence for inſtance, the whole foſſil kingdom

muſt

muſt be found therein: for all that tribe is convertible into fume. Gold, the moſt fixed of all, adheres to ſulphur in mines, and is raiſed along with it. All the parts of the animal kingdom muſt likewiſe be in the air. For beſides the copious effluvia they emit by perſpiration (where by an animal in the courſe of its duration, impregnates the air with many times the quantity of its own body) any dead animal, when expoſed to the air, is in a certain time carried wholly off. And we know that all vegetables by putrefaction become volatile, and ſo evaporate into air.

Air, 2. Volatilizes fixed bodies. Thus ſea-ſalt being calcined and fuſed, then expoſed to the air to liquify; when liquified, ſet to dry again; then fuſed again, and the operation thus repeated; will by degrees be almoſt wholly evaporated, nothing remaining but a little earth.

Air 3. Fixes volatile bodies. Thus though aqua-fortis or ſpirit of nitre, readily evaporates by the fire; yet if the air near be impregnated with ſpirit of urine, the volatile ſpirit is fixed, and falls down in a liquid form.

But the air's being open or encloſed, is of conſequence in chymical operations. So, to make ſulphur inflammable, a free air is required: in a cloſe veſſel it will not kindle. And thus all animals and vegetables can only be calcined in open air. In cloſe veſſels they never become any other than black coals.

By the air-pump the air is in a great meaſure drawn out of a veſſel called the receiver. And hence we learn how much all vital, nutritive and alterative powers depend upon the air. A candle in the exhauſted receiver uſually goes out in a minute. A kindled charcoal is totally extinguiſhed in about five minutes. Red hot iron is not affected thereby: only it will not light ſulphur or gunpowder, but melt it. Loadſtones act, as well as in the open air. Smoke ſinks in a darkiſh body to the bottom, leaving the upper part, clear and tranſparent. The ſyphon does not run therein: but attrition produces heat, as in the open air. If ſome grains of a heap of gunpowder be kindled by a burning-glaſs, they will not fire the contiguous grains. Glow-worms loſe their light as the air is exhauſted; but recover it

not

not on its re-admiſſion. Vipers and frogs ſeem dead in leſs than two hours, but recover in the open air. Snails live ten hours: efts two or three days; leeches five or ſix.

The atmoſphere is a body of air and vapours, which ſurrounds the globe to the height of at leaſt ſixty miles, gravitates towards its centre, and is carried along with it in all its motions. This continually preſſes on our bodies, with a weight equal to a pillar of air, whoſe baſe is equal to the ſurface of our bodies. Now a pillar of air of the height of the atmoſphere, is equal to a pillar of water thirty-two feet high. Every foot ſquare therefore of the ſurface of our bodies is preſſed on by a weight of air, equal to 35 cubic feet of water: and a cubic foot of water weighing 76 pound (troy weight) conſequently every foot ſquare of the ſurface of our bodies ſuſtains a pillar of air, equal to 2,260 pounds. If then the ſurface of a man's body contains fifteen ſquare feet, he ſuſtains a weight equal to 39900 pounds. This is the caſe, when the air is heavieſt. But the difference between the greateſt and the leaſt preſſure of air upon our bodies is equal to 3982 pounds.

Hence it is ſo far from being a wonder, we ſhould ſometimes ſuffer in our health, by a change of weather, that it is the greateſt wonder we ſhould not always ſuffer. For when we conſider our bodies are at ſometimes preſt upon by near two tons weight more than at others, it is ſurpriſing that every change does not break our whole frame to pieces.

In truth the veſſels of our bodies being ſo much ſtraitened by an increaſed preſſure, would ſtagnate the blood to the very heart, had not the Author of nature wiſely contrived, that when the reſiſtance to its circulation is greateſt, the force by which the heat contracts ſhould be ſo too. For upon an increaſe of the weight of the air, the lungs are more ſtrongly expanded, and the blood by being more intimately broken, made fitter for finer ſecretions, the nervous in particular, by which the heart is more ſtrongly contracted. On the other hand, when the weight of the ambient air is ever ſo little abated, the air contained within the blood, unfolds its ſprings, and forces the blood to take up a larger ſpace than it did before.

The reaſon we are not ſenſible of this preſſure, is well explained by Borelli: ſand perfectly rammed into a hard veſſel, cannot be penetrated, even by a wedge. And water in a bladder compreſſed on all ſides, cannot give way in any part. In like manner, within the ſkin of an animal, are contained various parts: ſome hard, as bones; ſome ſoft, as muſcles; and ſome fluid, as blood. Now it is not poſſible that bones ſhould be broke or diſplaced in the body, unleſs the preſſure lay heavier on one part than another. If the preſſure be ſo divided, that it be equal all round, upward, downward, ſideways, and no part of the ſkin to be exempt therefrom, it is plain, no fracture or luxation can follow.

The ſame may be obſerved of the muſcles and nerves, which though ſoft, yet being compoſed of ſolid fibres, do mutually ſuſtain each other, and reſiſt the common weight. The ſame holds of the blood and other humours. As water is not capable of condenſation, ſo theſe liquids, while contained in theſe veſſels, cannot be forced out of them by an univerſal compreſſion. Add to this, that the air itſelf which is contained in every part of the body, is ſuch a balance to the external air, that no hurt can enſue from its preſſure.

33. Oil of vitriol, when expoſed to the air, continually increaſes in weight. Let a phial of this ſtand unſtopped, and it will be conſtantly running over. Perhaps the cauſe of this odd phænomenon is, the moiſture contained in the air, which this liquor, a potential fire, imbibes as greedily, as actual fire does nitre.

34. At the height of forty-one miles, the air is ſo rarefied, as to take up three thouſand times the ſpace it does here. At fifty-three miles high, it would be expanded thirty thouſand times as much as it is here.

At that diſtance, (as was obſerved) it is expanded into three thouſand times the ſpace it occupies here. And we have ſeen it condenſed into the ſixteenth part of the ſame ſpace. It ſeems then, that the air is capable of being condenſed into the hundred and eighty thouſandth

thouſandth part of the ſpace it would take up when free from preſſure. But what texture muſt it be of, to make it capable of this immenſe expanſion and contraction? How imperfectly is this accounted for, by comparing it to wool, cotton, and the like elaſtic bodies.

35. But there is an amazing difference between the fixed, and the common air, with regard to their effects upon animal bodies. The fixed air, even when ſet free, and in a ſtate of perfect elaſticity, whether it be during the firſt ſtage of fermentation by fire, by effervescence, or by putrefaction; if it be received into the lungs of any animal, cauſes inſtant death. But the ſame air, when received into the ſtomach, whether thrown off by effervescent mixture in medicine, or extricated from the food by natural fermentation; in the firſt inſtance often operates likes a charm, in reſtraining vomitings; and in the ſecond is abſolutely needful, for the ſupport of life and health.

With regard to the common air, on the contrary no animal can live long without taking large quantities of it into the lungs. Yet if a ſmall portion of it be forced into the blood-veſſels of any animal, death preſently enſues.

So that theſe two ſpecies of air have quite different provinces, with reſpect to animal life. The firſt, common air, muſt mix wholly with the blood. The ſecond only communicates ſome ſubtle matter to it: probably electric fire, which we know is connected with every particle of common air.

CONTENTS

CONTENTS

OF THE

SECOND VOLUME.

CHAP. V. *Of Inſects.*

		Page
1.	Of their ſhape and make - - -	4
2.	Of their eyes - - - -	5
3.	Their heart, reſpiration - - -	6
4.	Their generation: particularly the ſilk-worm and ſilk-ſpider - - - -	ib.
5.	Of the common ſpider - - -	8
	Of various ſpecies of ſpiders that fly -	9
6.	Of the Tarantula, a kind of ſpider -	11
	The only remedy for the bite of the Tarantula is muſic - - - - -	ib.
	Two relations of the extraordinary effects of muſic - - - -	12
7.	Of the Coya - - - - -	13
	The uncommon effects of its ſting, and the only method of cure - - -	ib.
8.	Of microſcope animals - - -	14
9.	Of the flea - - - - -	15
10.	Of the louſe - - - - -	16
	Peculiarities of lice: their amazing increaſe	17

Many

Page

Many fiſhes, particularly ſalmon, incident to lice - - - 17
11. Of the death-watch - - - 18
Remarkable circumſtance of the beating of a death-watch - - - - ib.
Singular properties of the death-watch, the ſmalleſt of the beetle kind - 19
12. Of the eggs of flies - - 20
The eggs of inſects the occaſion of blights 22
13. Of gnats - - - 23
The uncommon propagation of gnats 24
14. Of the cicadula, or cuckoo-ſpit - 25
The cochineal - - ib.
15. Of the drone-fly - - ib.
16. Of the fire-fly of Jamaica - - 26
A perſon may read the ſmalleſt print by the light of one of theſe inſects - 27
17. Of the ephemeron, that lives but part of a day - - - ib.
Another ſort of ephemeron, called the May-fly: its remarkable properties - ib.
18. Of butterflies - - - 28
19. Of caterpillars - - 29
The caterpillar of the willow - 31
Peculiar circumſtances in caterpillars ib.
20. Of the tranſformation of inſects - 33
That of the caterpillar very remarkable throughout its various ſtates - ib.
21. Of ants - - - - 38
The extraordinary nicety of their neſts 39
Their beautiful appearance viewed through a microſcope - - - ib.
They eat not, but ſleep all the winter - 40
The remarkable architecture of ants - 41
The employment of working ants - 43
The red, green, and black ants of Africa 44
22. Of the ant-eater, or formica-leo - 45
His peculiar manner of enſnaring his prey, and various other extraordinary operations ib.
23. Of bees - - - 47
The habitation of bees - - 48
How honey is extracted - - 49
Of honey-dews - - ib.

A kind

Page

A kind of honey-dew produced by a ſmall inſect called the vine-fretter - - 50
Ants as fond of this as bees - - ib.
The curioſity of the ſting of a bee, or waſp ib.
The peculiar privileges attendant on, and homage paid to the queen bee - 51
The ſwarming of bees - - 53
24. Of the polypus - - 55
Of various corallines, a ſpecies of polypi ib.
The polypus, an acquatic animal, found in ditch-water - - - 57
Experiments on a polypus - - ib.
Cluſtering polypi more ſtrange than the reſt 58
The nature of corallines, and the mechaniſm of their polypi - - 60
The polypus is an animal of the vermicular kind - - - - 62
25. Of the tranſformation of animals - 63
Quadrupeds undergo a yearly change ib.
Viviparous animals have a more ſudden change - - - ib.
The tranſformation of oviparous animals 64
The transformation of tad-poles - ib.
That of the beetle-claſs, particularly the cock-chaffer - - ib.

CHAP. VI.

General Obſervations and Reflections.

1. Of the number of animals, the various ſpecies of beaſts, birds, fiſhes and inſects - 65
2. Of the different method of taking their food 66
3. That brutes are not mere machines 67
4. Of the natural inſtinct of all creatures 68
5. Of the clothing of various animals - 70
6. Of the admirable ſagacity of animals in the ſtructure of their habitations - - 71
7. Of the peculiar care of Providence over all his works - - - 72
8. The remarkable deſtruction and reparation of the whole animal creation - ib.

Page

9. Farther reflections on the world in general 74
10. A comparative view of the animal world, extracted from Mr. Hervey - - 77

PART THE THIRD.

CHAP. I. *Of Plants.*

1. What we mean by plants - - 83
2. Their liquid parts - - ib.
3. Their ſolid parts - - ib.
4. Of the bark - - - ib.
5. The wood - - 85
6. The pith - - ib.
7. The roots and branches - - ib.
8. The leaves - - 86
9. The nutrition of plants - - 87
10. Water not the nutriment of plants ib.
11. The motion or the nutritive juice 91
12. The deſcent and aſcent of the ſap 92
13. Of the increaſe of grains and ſeeds 93
14. Of male and female plants - - 94
15. Of the ſleep of plants - - 95
16. Of the agreement between plants and animals - - - 99
17. Of the generation of plants - - 103
18. Of their flowers - - ib.
19. Of their ſeeds - - 105
20. Of their fruits - - 112
21. Of the perſpiration of plants - - 114
22. Trees inverted will grow - - 116
23. Of the propagation of ſeveral plants 117
24. Of grain planted in various ſubſtances 120

CHAP. II.

1. Of ſome particular plants - 122
The ſubmarine graſs - - ib.
The ſubmarine ſenſitive plant - ib.
The vines of hops - - 123
The herb of Paraguay, or Catree, a ſpecies of tea - - - ib.

The

Page
The coco-tree - - - 124
The cacao-tree - - - ib.
The tallow-tree: the horſe-cheſnut: the ſago-tree - - - 125
Palm-trees: they are male and female 126
Sicilian plants: particularly cinnamon, ſarſaparilla, ſaſſafras, and Rhubarb - ib.
The balſam-tree - - 127
The flowering-aſh, whence manna is produced - - - - ib.
The Peruvian bark-tree - - ib.
The cotton-tree: the pepper ſhrub - ib.
The Jamaica pepper-tree - - 128
The plant which affords ginger - ib.
Of the produce of nutmegs - - ib.
The wild-pine - - ib.
The water-withy of Jamaica - 129
The fountain-tree of Hierro, one of the Canary Iſlands - - ib.
The machineel-apple: its poiſonous quality 130
Remarkable method of poiſoning by the Negroes in Africa - - 131
Of a plant like doronicum, wherein quick-ſilver is found - - 132
Of the aloe: its ſingular properties - ib.
The cereus, or prickly pear, of America 133
Peculiarities in the production of muſhrooms 134
Of ſea-plants: the coral in particular 135
2. Sugar not unwholeſome - - 136
3. Of Maple-ſugar - - ib.
4. Molaſſes made of apples - - ib.
5. Of ambergris - - - 137
6. Of the corruption of plants and animals ib.
7. General Reflections - - 143
8. Eſſay on the production, nouriſhment, and operation of plants and animals 154
Sect. 1. Creatures produce their own kind ib.
Sect. 2. The laws of nature ſufficient for the production of animals and vegetables 158
Sect. 3. Of the nouriſhment and growth of plants - - 159

Sect.

Page
Sect. 4. Of the nouriſhment and growth of animals - - - 162
Sect. 5. The ſimilar operations of plants and animals - - - 166

CHAP. III.

Of Metals, Minerals, and other Foſſils.

1. The variety of foſſils - - 172
2. The general properties of metals - - 173
3. Of the nutrition and generation of metals ib.
4. Of gold, ſilver, platina, copper, iron, tin, lead - - 174
The chief properties of gold - - ib.
The malleableneſs or ductility of gold beyond all imagination - - - 175
Silver comes the neareſt to gold in ductility and reſiſting fire - - 176
Of platina, an original metal between gold and ſilver, diſcovered in New Spain 177
It is extremely hard to melt - ib.
It comes neareſt to gold in weight of all other metals - - - ib.
Copper is next to ſilver in ductility - 179
How braſs is made - - ib.
Of iron - - - ib.
The arbor martis, a germination of iron, reſembles a natural plant - - 180
Various experiments - - ib.
5. Of ſteel - - - 182
6. Of quickſilver: its ſingular properties ib.
Copper and iron, gold and copper, ſilver and lead, tin and lead frequently found in one maſs 183
7. Of mines in general - - 184
8. Of mundic - - ib.
9. Of the fiſſures of the earth - 186
10. Of ſalts - - - 188
Remarkable ſalt-mines in Poland - ib.
11. Of ſtones - - 189
12. Of petrifying ſprings - - 191
13. Of copper ſprings - - 192

14. Of

Page
14. Of lime - - - 196
15. Of precious ſtones - - ib.
16. Of the loadſtone - - 199
17. Of inflammable foſſils - - 203
18. Of amber - - 204
19. Of linum aſbeſtum. - - ib.

PART THE FOURTH.

Of Earth, Water, Fire, Air, and Meteors.

CHAP. I. *Of Earth and Water.*

1. Of the formation of the earth. - 206
Of the earth's movement. - 207
2. Sand probably the earth's general cover 208
3. An inundation of ſand - - 209
4. Of mountains - - 210
5. The benefit of mountains - 211
6. The height of mountains - 212
Particular height of ſeveral mountains in France - - ib.
That of Mount Atlas - 214
Of the formation of mountains after the flood 216
Of the formation of an iron-mountain in Sweden - - 218
7. Of water - - - 219
The chief properties of water - 221
8. Of ice - 222
Rivers always freeze firſt at the bottom 223
Standing waters freeze firſt at the top 224
Surpriſing effects of ſevere froſt on trees and other vegetables - 225
The amazing bodies of ice near Hudſon's Bay 227
Some waters in Scotland which never freeze ib.
9. Of fountains - - - 228
Curious experiments, ſhewing, that vapour from the ſea ſupply all fountains and rivers - - - - 229
10. Of the ſea - - 231
11. Of rivers and iſlands - - 233

Of

		Page
	Of the greater rivers in Africa	233
	Deſcription of the river Nile -	ib.
	Peculiarities of the Thames water -	234
	Of the cataract of Niagara -	235
	American rivers the largeſt in the world	236
	The amazing length of the courſe of the Rhine - - -	ib.
	Of various freſh and ſalt-water lakes	237
	Of the formation of the main iſlands of the globe at the deluge -	239
12.	Of the baſon of the ſea. - -	ib.
	Of the little difference there is between the bottom of the Adriatic ſea and the neighbouring countries - -	242
	The greateſt and ordinary depths of the ſea	245
13.	Of the tides - -	246
14.	Of currents in the ſea -	247
	Methods of making ſea-water freſh	249
	Method of keeping freſh water ſweet	250
	Sketch of Mr. Hervey's reflections on what is obſervable in the terraqueous globe	ib.
	Curious remark of Dr. Cheyne concerning fluids in general -	263
	Of the iſlands of Scilly, ſo noted among the ancients - -	265
15.	Of ſubterraneous trees -	269
	Subterraneous trees in Italy -	270
	——————— Ireland -	271
	——————— Norfolk, Suffolk, Cambridge, Huntingdon, &c. &c. -	272
16.	Of the origin of bogs - -	273
	Of ſeveral bogs in Ireland - -	ib.
	Of ſome large ones in England -	274
	A remarkable one in Scotland -	277

CHAP. II.

1.	Of the effects and nature of fire -	280
	Of heating cold liquors with ice -	281
	Different degrees of heat in the ſame latitude	ib.
2.	Of the generation and nouriſhment of fire	282
3.	Of ſmoke and aſhes - -	283
	Fire is the inſtrument of all motion -	ib.

Of

Page
Of elementary and culinary fire - 283
How the effects of elementary fire may be increaſed - - - 284
Of ſubterraneous fire - - 285
4. Of burning mountains - - 286
5. Of Mount Ætna - - ib.
Recupero's account of Mount Ætna - 288
Kircher's account thereof - - - 289
Account of the eruption of it in 1669, and of another in 1755 - - - 290
6. Of Mount Veſuvius - - 291
Of an eruption thereof in 1754 - ib.
Of another eruption thereof in 1760 - 292
Uncommon fertility near Veſuvius - 293
Mr. Keyſler's account of Veſuvius - 294
Of the deſtruction of Herculaneum, Stabice, and Pompeii, cities near Naples, in the reign of Titus Veſpaſian - 295
Bracini's view of Veſuvius in 1631 - 297
Probability of the iſland of Madeira being thrown up by an exploſion of ſubterraneous fire - - - 298
7. Of Monte Secco, frequently called Veſuvius in miniature - - - 299
8. Of Monte Nuovo - - ib.
9. New iſlands - - - 300
10. Burning iſlands - - - ib.
11. Of Mount Hecla: particular account of a journey thither - - 301
12. Of Guadaloupe. Volcanos there, and in many of the American iſlands - 302
13. Of the pike of Teneriffe - - 303
14. Of earthquakes - - - 304
Various cauſes of earthquakes - ib.
Of artificial earthquakes - 305
Uncommon accounts of large rivers, and even ſeas, communicating by ſubterraneous paſſages - - 306
Pliny's account of Mount Cymbotus, a town, and a city, totally ſwallowed up - 308
Pliny's relation of fifty-four cities, and a great number of villages, ſwallowed by an earthquake - - - ib.

Page

Father Kircher's account of a dreadful earthquake at Calabria in 1638 - 309
15. Deſtruction of Port-Royal in Jamaica - 311
Account of that dreadful earthquake in 1692, by an eye-witneſs - - ib.
The Rector of Port-Royal's account of it 313
16. Deſtruction of Lima - - 314
17. ——————Callao, the port of Lima ib.
18. A remarkable deliverance from ſnow at a village under the Alps - - ib.
19. Of Poole's-hole, and Elden-hole in Derbyſhire - - - 318
Of the Giant's Cauſeway in Ireland - 319
Subterraneous fire of a harmleſs nature in Perſia. - - - ib.
20. Earthquakes cauſed by electricity - 320
21. Account of a burning well - 321
22. Of another at Broſely - - ib.
23. A fire of the ſame kind at Pietra Mala, a village on the Apennines - - 223
Another of the ſame kind, called Grotto del Cani, near Naples, with experiments of an Engliſh gentleman - ib.
24. A burning vapour in Wales - - 325
25. Perſons conſumed by internal fire - ib.
Sundry inſtances thereof abroad. - ib.
Two inſtances thereof in England - 327
26. Sparkles iſſuing from a perſon's clothes 328
27. Of glaſs - - - - ib.
Probable diſcovery thereof by accident in ſome Sidonian travellers - 329
28. Of the Bologna bottle: with curious experiments thereon - - - ib.
29. Of the glaſs-drop - - - 331
Of the invention of gun-powder - ib.
30. Of the nature and the properties of air - 332
The weight or gravity of air - - ib.
The elaſticity of air - - - 333
Experiments on air - - 336
Of the air-pump - - - 340

		Page
	Farther experiments on air - -	340
31.	Air is in all our fluids. - -	341
32.	Air is the cementing and diſſolving principle	343
33.	Air increaſes the weight of oil and vitriol	346
34.	Air is capable of immenſe expanſion	ib.
35.	Difference between fixed and common air	347

END OF THE SECOND VOLUME.

Special
collec.

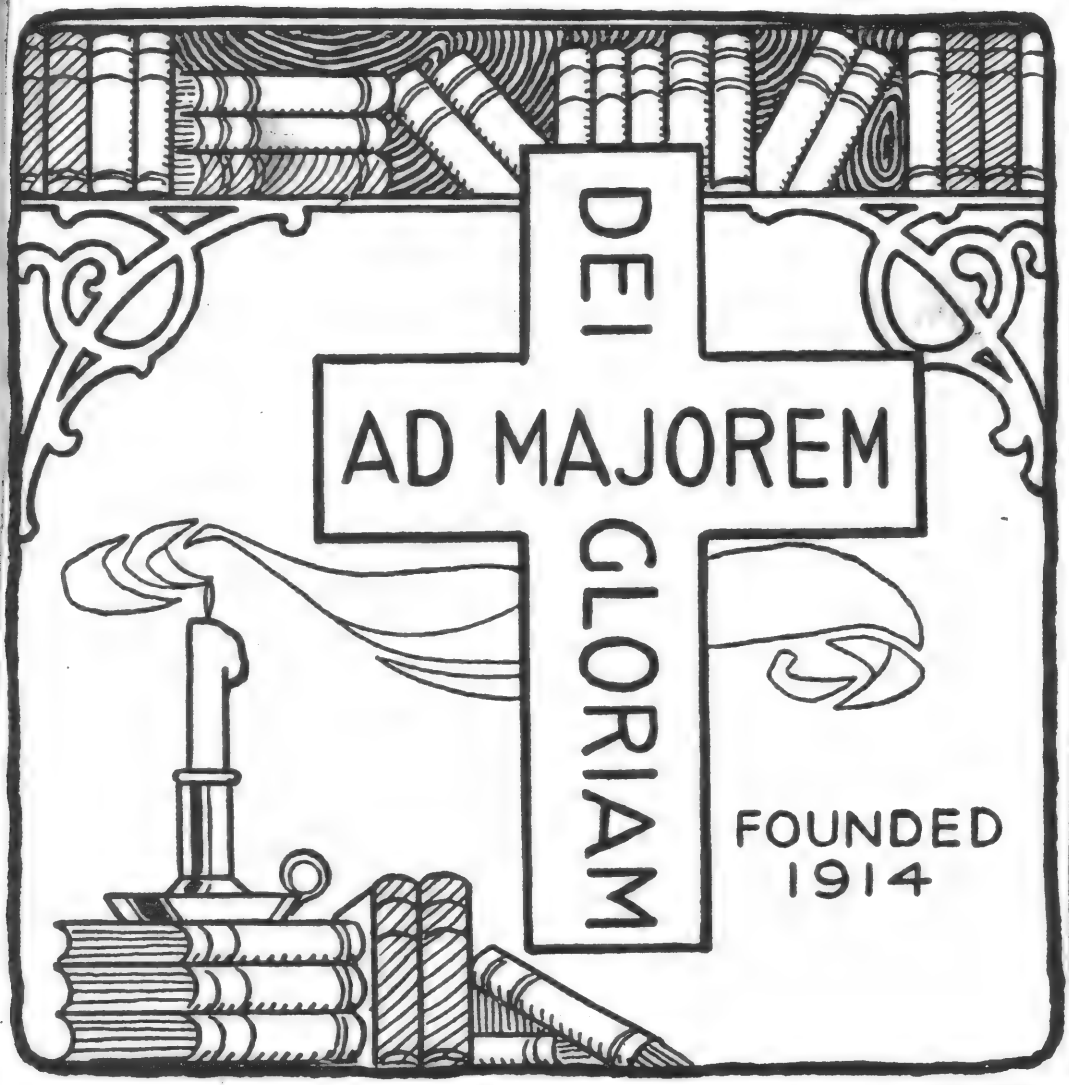
BW264
.W4S8
1810
v. 2

VOLUME 3

COLWELL,
Bookbinder.

BW2647
.W4S8
1810 v.3

School of Theology



THEOLOGICAL LIBRARY
Thursfield Smith Collection, No._____

Wes 298

A

SURVEY

OF THE

WISDOM OF GOD

IN

THE CREATION:

OR, A

COMPENDIUM

OF

NATURAL PHILOSOPHY.

IN FOUR VOLUMES.

By JOHN WESLEY, M. A.

THE SIXTH EDITION.

VOL. III.

These are thy glorious Works, Parent of Good,
Almighty! Thine this universal Frame,
Thus wond'rous fair! Thyself how wond'rous then!

MILTON.

DUBLIN:

PRINTED BY R NAPPER, 29, CAPEL-STREET;
And sold at the Methodist Preaching Houses in Town & Country

1810.

A

COMPENDIUM

OF

NATURAL PHILOSOPHY.

CHAP. III.

OF METEORS.

1. *Of Vapours, Miſts, and Clouds.*
2. *Of Dew and Rain.*
3. *Of Snow and Hail.*
4. *Of the Rainbow.*
5. *Of the Halo.*
6. *Of mock Suns and Moons.*
7. *Of Thunder and Lightning.*
8. *Of Damps.*
9. *Of Ignes Fatui.*
10. *Of Electricity.*
11. *Of Ether of Plants.*
12. *Of Wind.*
13. *Reflections.*

1. WHATSOEVER is carried aloft into the air, and ſuſpended there, is termed a meteor. Theſe are either watry, fiery or airy. The watry, are miſts, clouds, rain, ſnow, hail. Watry particles which

are rarefied ſo as to float in the air, are theu termed vapours. If theſe are viſible and hang near the earth, we call them miſts; if they are higher in the air, clouds. Some of theſe are ſo thin, as to tranſmit the rays of the ſun, others ſo denſe as to intercept them.

The manner wherein the vapours that conſtitute clouds and rain are raiſed, ſeems to be this. Fire being the lighteſt of all bodies, eaſily breaks looſe from them; and its paſſage carries along with it particles or little caſes of water. Theſe being lighter than the air, are buoyed up and ſwim therein: till ſtriking againſt one another, or thickened by cold, they are reduced into clouds and drops.

To illuſtrate this, we may obſerve in water over the fire, 1. That the evaporations are proportioned to the heat. A ſmall heat throws off few vapours, ſcarce viſible: a greater heat carries off larger and more numerous veſicles of water, which we call a ſteam. Violent heats lifts up great quantities of water, which the air cannot buoy up: and this we call boiling. 2. If theſe vapours be intercepted in their aſcent, by any denſe body, eſpecially if it be cold; they are thereby reduced into drops, like thoſe of rain. 3. In froſty weather the vapours riſe but a little above the water, and there hang or glide on. If the weather be cold; after a little aſcent, they fall again into the water. But in a warm ſtill air, they aſcend ſwiftly and largely, and mount up, till they are out of ſight.

To explain this a little farther, it may be obſerved, that the parts of water being ſo ſmall and moveable, are eaſily ſeparated from one another. And when they are ſo divided into ſmall parcels, as to become about eight hundred times lighter than common water, they are as light as the air, and will by every ſucceſſive degree of ſeparation, riſe in the air in proportion to their lightneſs, the heavier air forcing the rarefied fluid to aſcend into the atmoſphere, till it finds a place in equilibrium among bodies of equal lightneſs to itſelf. This ſeparation or comminution (if I may ſo call it) of water into ſmall parcels, may be performed either by colliſion againſt harder and more compact bodies, or by heat. The firſt we often ſee performed at the bottom of caſcades, where the water that falls

but

but a few fathoms, ſhall riſe in a miſt from the bottom where it is broke ; and there are inſtances of clouds riſing from the fall of waters, which may be ſeen five miles of. Colliſion will therefore excite vapours : but what is more conſtantly producing this effect in every part of the univerſe, is heat : whether from the ſun, which is always buſy this way, or from artificial ignition, or that generally inviſible elemental fire, which is diſtributed through all matter. It is not neceſſary for us to conſider in this caſe, any other than the diviſibility of water, and the inſinuating and diſperſive qualities of fire. Fire we ſee ſeparates more or leſs the parts of all bodies, whether fluid or ſolid, and makes them riſe in the air ; and it does no more to water : it ſeparates it into ſuch ſmall portions, that the air is more ponderous than the ſteam, and of conſequence remains nearer the earth by its ſuperior gravitation.

2. The dew which uſually falls in England in a year, amounts to ſomething more than three inches and a quarter depth. The evaporation of a winter's day is nearly the ſame as that of a ſummer's day. For the earth being moiſter in winter, that exceſs of moiſture anſwers to the exceſs of heat in ſummer.

Within the tropics they have no rain for many months together. But the dews are far greater than with us. Yet the moiſture evaporated in a ſummer's day, far exceeds that which falls in the night. Hence the dews there, cannot be of any benefit to the roots of the trees, becauſe they are remanded back from the earth by the following day's heat, before they can ſoak to any conſiderable depth. The great benefit therefore of dew in hot weather muſt be, by being imbibed into vegetables, to refreſh them for the preſent, and ſupply them with moiſture towards the expence of the ſucceeding day.

Mean time the ſun draws freſh ſupplies of moiſture from the ſtrata of the earth, which by means of its penetrating warmth inſinuates itſelf into the roots. By the ſame genial heat it is carried up through their bodies and branches, and thence paſſing into the leaves, it is vigorouſly acted upon in thoſe thin plates, till perſpiring through their ſurface, it mounts with rapidity in the free air.

But the ſtrangeſt circumſtance relating to dew, is

this. In the ſame night place ſeveral ſubſtances in the open air, whilſt a large dew falls: and ſome of them will receive much of it, ſome little, and others none at all. The drops make a ſort of choice, what bodies they ſhall fix themſelves to. Glaſs and cryſtals they fix themſelves to readily, and in the largeſt quantities. Metals do not receive them at all, nor do the drops ever fix on them. If a glaſs veſſel be ſet out in the evening, on a ſilver plate, the glaſs will be found quite covered with dew, and the ſilver perfectly dry. China-ware is a ſort of glaſs. Six pounds of mercury being expoſed to the air in a china-plate, the dew ran in ſtreams on the edge of the plate, but not a drop was on the mercury.

Is there not ſome alliance between the phænomena obſerved in dew, and thoſe which appear in electric bodies? All hard bodies may by rubbing become electric, excepting only metals. And metals are the only bodies which wholly refuſe to admit dew.

But this is not all. A pewter plate placed all night in the open air, receives no dew on its upper-ſide, but the under-ſide is covered with it. On the contrary, place a china-plate near it, and the upper ſide of it is quite wet, but the under-ſide is quite dry. So one receives the dew only on the upper, the other only on the under ſurface! Who can account for this?

Mr. Kerſhaw has obſerved, that dew newly gathered and ſtrained, is not very clear, but of a yellowiſh colour:

That when he endeavoured to putrefy it by various degrees of heat, he quite failed of his intention: for heat rather clarified and preſerved it ſweet, than cauſed any putrefaction:

That after it had been expoſed to the ſun, corked up, for a whole ſummer, there was no other change than that much green ſtuff (ſuch as we ſee in ſtanding water) floated on the top:

That after it had been expoſed to the ſun many weeks in an open glaſs, it was full of little inſects, like tadpoles, which in a while dropt their ſkins, and became gnats:

That vapouring away great quantities of this dew, he

he procured two pounds of greyiſh earth which lay in leaves one above another, like brown paper, but very friable:

Laſtly, that by often calcining and filtring this earth, he extracted two ounces of a fine, ſmall, white ſalt, which much reſembled rock ſalt, when it was viewed through a microſcope.

If clouds are condenſed, ſo as to fall in drops, this we ſtile rain. It may riſe from various cauſes. Sometimes cold alone condenſes a warm cloud. But it is generally wind which preſſes the cloud ſo cloſe together, that the particles of water unite in large drops, which being ſpecifically heavier than the air, can no longer be ſuſpended by it.

But by what power are the drops of rain ſo equally diſperſed? This may be ſhewn by an eaſy experiment. Put a quantity of braſs-duſt into an electric phial. When this is charged, invert it, and throw ſome of the duſt out. This will be ſpread over a flat ſurface, with exact uniformity, and will fall juſt like rain or ſnow. It is highly probable, this is the caſe with the clouds. Being highly electrified, they of courſe ſpread their contents equally over the ſurface of the earth.

Again. How comes it to paſs, that we have not conſtantly either too much or too little rain in any one place? It is not chance, which can never ſteer clear of extremes. It is the hand of Providence. There is no other rational way of accounting for ſuch an œconomy in the clouds. Such a juſt and neceſſary diſtillation and diſtribution of water from the grand alembic of the atmoſphere, could never proceed, but from the ſuperintendance and direction of that Omnipotent Chymiſt, in whoſe hands are all the ſecondary powers of nature, to vary their operations, as he ſees moſt conconducive to the general good of mankind.

Bloody rains, as they have been ſometimes called, ſeem to be only the excrements of inſects. Accordingly Gaſſendus gives us an account of a bloody rain in France which much terrified the people. But upon inquiry,

inquiry, it was found only to be red drops, coming from a ſort of butterflies which flew about in great numbers.

During a ſcarcity in Sileſia, a rumour was ſpread, of its raining millet-ſeed. But it was ſoon found to be only the ſeeds of the ſmall henbit, growing thereabouts in great plenty. So in the Archipelago it was thought aſhes were rained, with which ſhips were covered for many leagues. But in truth, they came from an eruption of Veſuvius happening at that time. More lately, it was reported at Warminſter, in Wiltſhire, that it rained wheat. But the ſuppoſed wheat was really ivy-berries, blown thither in a conſiderable quantity by a hurricane. Nay, in 1696 a field near Cranſtead in Kent, was overſpread with young whitings, ſuppoſed to fall from the clouds, but doubtleſs brought thither from the ſea, by a violent ſtorm.

Nor is it ſtrange that any of theſe things ſhould be thus tranſported by tempeſtuous winds, conſidering to what diſtance, and in what quantities the ſea-water was carried by the ſtorm, Nov. 26, 1703. A phyſician travelling ſoon after, twenty miles from the ſea, chewing ſome tops of hedges, found them ſalt. The graſs of the down about Lewes, was ſo ſalt, that for ſome time the ſheep could not eat it. And the miller, three miles from the ſea, attempting with his man to ſecure his mill, were ſo waſhed with flaſhes of ſea-water, that they were almoſt ſtrangled.

A few years ago, during a violent ſtorm of wind, much rain fell in the weſtern part of Cornwall, which was mere ſea-water, as ſalt as that which was juſt taken out of the ſea. It ſeemed to have been drawn out of the ſea, and thrown upon the land in the ſame hour: ſo that there was no time for that wonderful operation of nature, whereby the water that aſcends in clouds, is freed from its ſalt and bituminous particles, before it falls to the earth.

3. When the particles of water in a cloud are frozen, it occaſions ſnow, which floats in the air till it is driven together, ſo as to be heavy enough to ſink.

When

When the drops of rain in falling toward the earth, meet with a ſtream of cold air, they are often froze into ice, and ſo fall to the ground in the form of hail. Hence the reaſon appears, why ſnow, which is only frozen miſt, is lighter than either rain or hail.

But why is ſnow, though it ſeems to be ſoft, truly hard? Becauſe it is true ice. It ſeems ſoft, becauſe at the firſt touch of the finger on its ſharp edges or points, they melt. Otherwiſe they would pierce the finger, juſt as ſo many lancets.

But why, though it be true ice, which is a hard and denſe body, is it ſo very light? Becauſe of the extreme thinneſs of each circle, in compariſon of its breadth. So gold, the moſt ponderous of all bodies, when beaten into leaves, rides upon the air.

Why is it white? Becauſe its parts, though ſingly tranſparent, yet muſt appear white when mixed together, as do the parts of froth, of powdered glaſs, and other tranſparent bodies, whether ſoft or hard.

You will ſee ſnow of a peculiar kind, if you try the following experiment. Set a tall phial of aquafortis by the fire, till it is warm. Then put in filings of pure ſilver, a few at a time, and after a briſk ebullition, the ſilver ſlowly diſſolves. Place this in a cold window. As it cools, the ſilver particles ſhoot into cryſtals, ſeveral of which running together, form a flake of ſnow, and deſcend to the bottom of the phial. While they are deſcending, they perfectly repreſent a ſhower of ſilver ſnow. And the flakes lie upon one another at the bottom, like real ſnow upon the ground.

Many particles of ſnow are of a regular figure, like rowels, or ſtars of ſix points. On each of theſe points are other collateral ſtars, but many of the points are broken. Others have been thawed, and are froze again into irregular cluſters. All theſe are perfect ice, ſo that the whole of ſnow is an infinite number of icicles. A cloud of vapours condenſing, forthwith deſcends, till meeting with a freezing air, each drop immediately becomes an icicle, ſhooting itſelf into ſeveral points. Theſe deſcending ſtill, and either ſtriking on each other, or meeting with gales of warmer air, are a little blunted or thaw-

ed, and froze again into cluſters, and ſo entangled as to fall in flakes.

Even in our temperate climate, we have ſometimes had very extraordinary ſhowers of hail. On April 29, 1697, a thick black cloud, coming from Carnarvonſhire, poured ſuch a hail on Cheſhire, Lancaſhire, and ſome other counties, that in a line two miles broad and ſixty miles long, it did inconceivable damage. It not only killed all ſmall animals, but ſplit trees, and beat down horſes and men. The hail-ſtones, many of which weighed five ounces, ſome ſeven or eight, were of various figures: ſome round, others half round, ſome ſmooth, others emboſſed, or variouſly granulated. The icy ſubſtance of them was tranſparent and hard; but there was a ſnowy kernel in the middle of each.

May 4, in the ſame year, there was a ſhower of hail, in Hertfordſhire, which exceeded this. Fields of rye were cut down as with a ſcythe: ſeveral men killed, and vaſt oaks ſplit. The ſtones were from ten to fourteen inches round, ſome oval, ſome picked, and others flat.

Mezeray relates that in Italy, in 1510, there was, after a horrible darkneſs, a ſhower of hail which deſtroyed all the fiſh, birds and beaſts of that country. It was attended with a ſtrong ſmell of ſulphur. Some of the ſtones weighed a hundred pounds.

4. The rain-bow is always ſeen in the region oppoſite to the ſun, and never but when it rains on that ſide. Its colours are conſtantly in this order; the outermoſt red, the next yellow, the third green, the innermoſt violet colour: but theſe are not always equally vivid. When two rainbows appear, the upper exhibits the ſame colours, but fainter, and in an inverted order. The ſeat of the rainbow is the drops of rain, on which the rays of the ſun fall, and after various refractions and reflections, ſtrike on the eye of the beholder. This is rendered indiſputable from hence, that the very ſame colours, and in the ſame order, are exhibited in the drops of water, ſpouted from a fountain.

The

The moon alſo ſometimes exhibits a rainbow: but only when ſhe is full: her light being at other times too faint to affect the ſight, after two refractions and a reflection. It has all the colour of the ſolar rainbow, very diſtinct and pleaſant, only conſiderably fainter.

A rainbow is likewiſe ſometimes exhibited by the ſea, when a ſtrong wind carries the tops of the waves aloft, and the ſun's rays falling upon them are refracted and reflected, as in a ſhower. But the colours of this are leſs lively, leſs diſtinct, and leſs durable than thoſe of the common bow. Scarce above two colours are diſtinguiſhable, a dark yellow on the ſide next the ſun, and a pale green on the oppoſite ſide. But ſometimes twenty or thirty of them are ſeen at once. They appear at noon-day, in a poſition oppoſite to that of the common rainbow, the concave ſide being turned upwards.

5. Halo's are circles of various colours, which are ſometimes ſeen about the ſun or moon. The ſpace contained within them (eſpecially near thoſe parts which are tinctured with the moſt lively colours) is more duſky than the ſky without. (They never appear in rainy weather.) Perhaps the air is at that time full of very ſmall icy particles, on which the rays of the ſun and moon falling, after refraction, exhibit that appearance.

6. As to mock ſuns, we ſometimes ſee a large, white circle, parallel to the horizon, in ſeveral parts whereof more or fewer ſuns appear, though not always of the ſame ſize or colour. As an halo frequently appears at the ſame time, it is probable they ſpring from much the ſame cauſe, namely, from icy particles floating in the air, between the ſun and the eye of the ſpectator. The rays of the ſun reflected from theſe, may form that bright circle, in certain parts whereof, by a double refraction and reflection of them, thoſe fictitious ſuns appear. In the ſame manner, the appearances termed mock moons may be accounted for.

7. Among

7. Among fiery meteors are reckoned, thunder, lightning, ignes fatui, lambent flames, and what are called, falling ſtars. Unleſs we account for theſe (as indeed it is eaſy to do) upon the principles of electricity, we muſt ſuppoſe they are owing to ſulphureous or bituminous particles, floating in the air, which when collected in ſufficient quantities, take fire by various means. If a large quantity of inflammable vapour takes fire at once, the flame tears the cloud with incredible force, as well as immenſe noiſe. But the light moving ſwifter than the ſound, is ſeen before that is heard. Sometimes an exhalation of a milder kind takes fire, and produces lightning without thunder. When it thunders and lightens, it commonly rains too, the ſame ſhock driving together and condenſing the clouds. And the wiſdom of God appoints it ſo, for the preſervation of his creatures. For if lightning falls on one who is thoroughly wet, it does him no harm at all. Not that the water quenches or reſiſts the fire; but it conveys it into the ground.

High places are moſt frequently ſtruck with lightning, if they have ſharp points, as ſpires of churches, or tops of trees, which as it were, attract the fire. It ſometimes burns the clothes without hurting the body; ſometimes breaks the bones without ſcorching the ſkin. It melts the ſword in the ſcabbard, or money in the pocket, while the ſcabbard or pocket remains as it was. In general, it paſſes innocently through thoſe things that make little or no reſiſtance; but tears thoſe in pieces with impetuous force, which reſiſt its paſſage.

One very particular effect of lightning, is what the vulgar call, Fairy Circles. Theſe are of two kinds. One kind, is a round, bare path, about a foot broad, with green graſs in the middle, and is frequently ſeven or eight yards in diameter. The other is a circle of the ſame breadth, of very green graſs, much freſher than that in the middle. Theſe are generally obſerved after ſtorms of thunder and lightning. And it is no wonder, that lightning, like other fires, moves circularly, and burns more at the extremity than in the middle. The ſecond kind of circles without all doubt ſpring originally from the firſt: the graſs, which was burnt up

by

by the lightning, growing afterward more freſh and green.

But of what kind was that meteor which appeared March 21, 1676? Two hours after ſun-ſet, it came over the Adriatic ſea, from E. N. E. to W. S. W. and croſſed over all Italy, being nearly vertical to Rimini on the one ſide, and Leghorn on the other. It was at leaſt thirty-eight miles high. In all places near its courſe, it made a hiſſing noiſe like a ſky-rocket. Having paſſed Leghorn, it gave a ſound like that of a large cannon, and quickly after like a cart, running over ſtones. It was computed to move 160 miles in a minute, which is above ten times as ſwift as the diurnal motion of the earth. Its ſmaller diameter was judged to be above half a mile. No wonder then, that ſo large a body, moving with ſuch incredible ſwiftneſs through the air, though ſo much rarefied, ſhould cauſe that hiſſing noiſe. It is much harder to conceive, how ſuch an impetus could be impreſſed upon it: how this impetus ſhould be determined in a direction ſo nearly parallel to the horizon. And what ſort of ſubſtance it muſt be, that could be ſo impelled and ignited at the ſame time. Whatever it was, it ſunk, and was extinguiſhed in the Tyrrhene Sea, to the W. S. W. of Leghorn. The great noiſe was heard, on its immerſion into the water, the rattling ſound upon its quenching.

On Thurſday, March 19, 1719, there appeared at London, about eight at night, a ſudden great light, moving after the manner, but more ſlowly than a falling ſtar, in a direct line, a little beyond and withal below Orion's Belt, then in the ſouth-weſt. In its way, it turned tapering upward, and at laſt ſpherical, near as big as the full moon. It was whitiſh, with an eye of blue, as bright as the ſun in a clear day. It ſeemed in half a minute to move twenty degrees, and to go out as much above the horizon. There remained after it for more than a minute, a track of reddiſh colour, ſuch as that of red-hot iron; and ſparks ſeemed to iſſue from it, ſuch as come from red-hot iron, beaten upon an anvil.

Within

Within doors the candles gave no light; and without, not only the ſtars diſappeared, but the moon, nine days old, though the ſky was clear, and ſhe was then near the meridian: ſo that for ſome ſeconds, we had perfect day. Its height was ſeventy-three miles and a half. Hence it might be ſeen in all places, which were not diſtant from it more than two hundred and twenty leagues. Accordingly, it was ſeen at the ſame inſtant, over Spain, France, Great Britain, Ireland, Holland, and the hither parts of Germany.

Another appearance, which reſembles lightning is the Aurora Borealis, commonly called northern lights. This is uſually of a reddiſh colour, inclining to yellow, and ſends out coruſcations of bright light, which ſeem to riſe from the horizon in a pyramidical form, and ſhoot with great velocity into the zenith. It appears frequently in the form of an arch, riſes far above the regions of the clouds, yet never appears near the equator, but always nearer the poles.

8. Vapours of the ſame kind, that give riſe to lightnings in the air, occaſion damps in the earth. The damps uſual in mines are of four ſorts. The approach of the firſt and moſt common is known by the flame of the candle leſſening till it goes out: as alſo by the men's difficulty of breathing. Thoſe who eſcape ſwooning are not much hurt on this: but thoſe who ſwoon away, are commonly on their recovery ſeized with ſtrong convulſions. The ſecond is the Peaſbloom damp, ſo called becauſe of its ſmell. This comes only in ſummer, and is common in the peak of Derbyſhire. They who have ſeen the third ſort of damp, deſcribe it thus. In the higheſt part of the roof of thoſe paſſages in a mine, which branch out from the main grove, a round thing hangs about as big as a foot-ball, covered with a thin ſkin. If this be broken, the damp immediately ſpreads, and ſuffocates all that are near. But ſometimes they contrive to break it at a diſtance; after which they purify the place with fire. The fourth is the fire-damp: a vapour, which if touched by the flame of a candle, takes fire, and goes off like gunpowder. And yet ſome who have had all their clothes burnt off by one of theſe, and their fleſh torn off their bones,

bones, at the very time felt no heat at all, but as it were cool air.

Sir James Lowther, having collected ſome of the air in bladders, brought it up to London. Being let out at the orifice through a tobacco-pipe, it would take fire at the flame of a candle. And even this is imitable by art. Moſt metals emit ſulphureous vapours, while they are diſſolving in their ſeveral menſtruums. Iron for inſtance, while it diſſolves in oil of vitriol, emits much ſulphureous vapour. If this be received into a bladder, and afterwards let out in a ſmall ſtream, it takes fire juſt in the ſame manner as the natural vapour.

This experiment explains one cauſe of the earthquakes and volcanos; ſince it appears hence, that nothing more is neceſſary to form them, than iron mixing with vitriolic acid and water. Now iron is generally found, accompanied with ſulphur; and ſulphur conſiſts of an inflammable oil, and an acid like oil of vitriol.

This acid in the bowels of the earth, being diluted with a little water, becomes a menſtruum to iron, with a violent efferveſcence and an intenſe heat. The air coming from this mixture is extremely rarefied, and the more it is compreſſed by the incumbent earth, ſo much the more its impetus will be increaſed to an unlimited degree. Nor does there need fire to ſet theſe vapours to work. The air in the bladder, if it be much heated, will of itſelf take fire, as ſoon as it is brought into contact with the external air.

Other damps are ſometimes as mortal as thoſe in mines. In the year 1701, a maſon being at work in the city of Rennes, near the brink of a well, let his hammer fall into it. A labourer who was ſent down for it, was ſuffocated, before he reached the water. A ſecond ſent to draw him up, met with the ſame fate. So did a third. At laſt a fourth, half drunk, was let down with a charge to call out immediately, if he felt any inconvenience. He did call, as ſoon as he came near the water, and was drawn up inſtantly. Yet he died in three days, crying out, he felt a heat, which ſcorched his entrails. Yet the three carcaſes being drawn

up

up with hooks, and opened, there appeared no cauſe of their death.

The ſame hiſtorians relate, that a baker of Chartres, having carried ſeven or eight buſhels of brands out of is oven into a cellar 36 ſtairs deep, his ſon, a ſtrong young fellow, going with more, his candle went out on the middle of the ſtairs. Having lighted it afreſh, he no ſooner got into the cellar, than he cried for help, and they heard no more of him. His brother, an able youth, ran down, cried, " I am dead," and was heard no more. He was followed by his wife, and ſhe by a maid, and ſtill it was the ſame. Yet a hardy fellow reſolved to go and help them; he cried too, and was ſeen no more. A ſixth man deſired a hook to draw ſome of them out. He drew up the maid, who fetched a ſigh and died. Next day one undertook to draw up the reſt, and was let down on a wooden horſe with ropes, to be drawn up whenever he ſhould call. He ſoon called, but the rope breaking, he fell back again, and was a while after drawn up dead. Upon opening him the membranes of the brain were found extremely ſtretched, his lungs ſpotted with blood, his inteſtines ſwelled as big as one's arm, and red as blood, and all the muſcles of his arms, thighs, and legs, torn and ſeparated from their bones.

Whence this ſtrange difference ſhould ariſe, that the vapours of ſome mines catch fire with a ſpark, and others only with a flame, is a queſtion that we muſt be content to leave in obſcurity, till we know more of the nature both of mineral vapour and fire. This only we may obſerve, that gunpowder will fire with a ſpark, but not with the flame of a candle: on the other hand, ſpirits of wine will flame with a candle, but not with a ſpark. But even here the cauſe of this difference remains a ſecret.

A like inſtance of the fatal nature of foul air, happened at Boſton, in New England. Mr. Adams and his ſervant being employed to repair a pump, uncovered the well, and Mr. Adams went down by a rope; but he had not gone ſix feet before he dropt ſuddenly without

without ſpeaking a word, to the upper part of the joint of the pump, where being ſupported about a minute, and breathing very ſhort, he then fell to the bottom, without any ſigns of life. His ſervant haſtily went down to help his maſter; but at the ſame diſtance from the top, was ſtruck, and without diſcovering any ſigns of diſtreſs, fell to the bottom. The workmen prepared a third, with a tacle about his waiſt. On his deſcent, he was quickly ſpeechleſs and ſenſeleſs. Though he made no ſign, they drew him up. He was the very picture of death, but by the uſe of proper means recovered. He remembered nothing of what had paſſed. The other bodies when taken up, had all the marks of a violent death.

The vapour of fermenting liquors is equally extraordinary in its effects. This vapour appears over the fermenting liquor as a fog in a meadow, but more fleecy. It is heavier than air, and falls quick to the ground and diſappears. Van Helmont calls it, Gas Sylveſtre. Boerhaave ſays, " There is nothing more ſurpriſing in fermentation, than the Spiritus Sylveſtris, nor is there any poiſon that I am acquainted with, ſo ſubtle, ſwift, and fatal. For if a very large veſſel full of muſt, in the very act of fermentation, ſhould diſcharge this ſpirit through a ſmall vent-hole in the top of the veſſel, and the ſtouteſt man ſhould apply his noſe to the hole, and at once draw in this vapour, he would drop down dead in an inſtant, without any apparent cauſe of it. It extinguiſhes flame inſtantaneouſly. If a lighted candle be let ſlowly into it, the flame is borne up from the wick, and the candle may be raiſed up again ſo as to receive the flame." One put a mouſe into it, which was killed in about a ſecond of time, it kicked once or twice, and then was quite dead.

May we aſcribe to a kind of damp, a ſort of murrain, which appeared in Italy, and made great havoc among the cattle? It ſpread itſelf in the form of a blue miſt, over thoſe paſtures where they grazed: ſo that whole herds came home ſick, and moſt of them died in twenty-four hours. Many who went among them,

them, were infected, and died in the ſame manner. Some imputed this contagion to noxious vapours, thrown out of the earth, by earthquakes preceding. It paſſed through Germany to Poland, going without intermiſſion, eleven or twelve miles in twenty-four hours, and ſuffering no cattle in its way to eſcape, whether within doors or without. Hence others imagined it was owing to ſome volatile inſect, which was able to make but ſhort flights.

9. Ignus Fatuus, vulgarly call Will with the Wiſp, is chiefly ſeen in dark nights, irregularly moving over meadows, marſhes, and other moiſt places. It ſeems to be a viſcous exhalation, which being kindled in the air, reflects a kind of thin flame in the dark, though without any ſenſible heat. It is often found to fly along rivers or hedges, probably becauſe it there meets with a ſtream of air to direct it. In Italy there are luminous appearances, nearly reſembling theſe, which on a cloſe inſpection have been found to be no other than ſwarms of ſhining flies.

In all the territories of Bologna, theſe fiery appearances are common. There are ſome places where one may be almoſt ſure of them, every dark night, as near the bridge Della Salcarata, and in the fields of Bagnara, theſe are large: ſometimes equal to the light of a faggot, rarely leſs than that of a link. That at Bagnara not long ſince kept a gentleman company for a mile, moving juſt before him, and caſting a ſtronger light on the road than the link he had with him.

All of them reſemble a flame, and are continually in in motion, but the motion is various and uncertain. In winter, when the ground is covered with ſnow, they are moſt frequent of all. Nor does rain hinder them: nay, in wet weather they give the ſtrongeſt light: wind alſo does not diſturb them. As they are not hindered by wet, and ſet nothing on fire, though ever ſo combuſtible, may it not reaſonably be ſuppoſed, that they have ſome reſemblance to that kind of phoſphorus, which ſhines indeed in the dark, yet does not burn like common fire?

The following experiments ſhew a little more of the nature of this ſtrange ſubſtance.

Salt of phoſphorus, kept in a vitrifying heat, at laſt runs into perfect glaſs. What a wonderful ſubject is this? And how ſurpriſing it is, that ſo inflammable a body ſhould become glaſs! Here then is perfect tranſmutation of bodies: the phoſphorus being tranſmuted into a tranſparent glaſs of a bluiſh green, coming nearer the hardneſs of a diamond, than any other glaſs whatever. And the glaſs is in the very ſame quantity with the phoſphorus, which produces it ounce for ounce.

Another odd circumſtance relating to phoſphorus is, cut it ſmall, or ſcrape it with a knife, and lay it on a glaſs diſh in moiſt air. In a week it reſolves into a liquid, near eighty times its original weight. This liquid is the ſame in all reſpects, with that which comes from the ſublimed flowers by deflagration. And this may be turned into the ſame glaſs with the original phoſphorus. One of the moſt ſingular kinds of lambent fires is that diſcovered at certain times on ſea-water. Where the ſhip goes ſwiftly in the night, in many ſeas the whole breaking of the water will appear behind it, as if on fire, ſparkling and ſhining all the way that it moves from the ſhip.

It is in this part as bright and glittering as if the moon ſhone upon it, and chiefly when there is neither moon or ſtars, nor any light in the lanterns. But it is not always the ſame: ſometimes it is ſcarce perceivable, ſometimes very vivid and bright. Sometimes it is only juſt behind the ſhip, ſometimes it ſpreads a great way on each ſide. It commonly reaches thirty or forty feet from the ſtern of the ſhip, but is fainter as it is farther off. At the ſtern it is often ſo bright, that a perſon on deck may ſee to read by it. The luminous water that follows the ſhip is ſometimes diſtinct from the reſt of the ſurface. Sometimes it is ſo blended with the adjacent water, that the appearance is confuſed. The luminous matter ſeems compoſed of ſmall ſparkles, which are ſometimes in the figure of a ſtar, ſometimes it forms globules, without any radiations from them. Theſe are, ſome of the ſize of a large

pin's

pin's head; ſome larger, even to a foot in diameter. Sometimes the luminous matter is in oblong ſquares, of three or four inches. When the ſhip goes ſwiftly, theſe figures all combine and form a ſort of luminous whirlpool. Nor does a ſhip only, but whatever moves ſwift through the ſea, cauſe the ſame appearance. Large fiſh when they ſwim near the ſurface, leave a luminous road between them. So have a number of fiſh moving together. And ſometimes the throwing out a rope, or any thing that breaks the ſurface of the water, will render it luminous. If ſea-water be taken up, and placed in a veſſel, as ſoon as it is ſtirred, it will ſparkle: and if a linen rag be dipped in ſea-water, and hung up, when it is thoroughly dried, it will appear luminous on being rubbed in the dark; and when half dry, it need only be ſhook, to ſhew a great number of ſparkles. When theſe ſparkles are once formed, and fall on any ſolid body, they will laſt a conſiderable time. If they remain on the water, they will ſoon go out.

The waves beating againſt the rocks or ſhore, yea, or againſt one another, will occaſion the ſame appearance, and often yield a long courſe of light the whole night. In the Braſils the ſhores often ſeem all on fire, by the waves daſhing againſt them. In general, the thicker and fouler the ſeas are, the more of this light they afford. In many places the ſea is covered with a yellowiſh matter like ſaw-duſt, which ſeems to be the excrement of ſome ſea-animal. The water where this is found, gives more light, upon moving, than any other.

Some parts of the northern ſeas are covered with this, for ſeveral leagues together, and this is often luminous all over in the night, though not ſtirred by any thing moving through it.

In the gulf of Venice the water is luminous, only from the beginning of ſummer till the end of harveſt. This light is moſt copious in places abounding with ſea-graſs, eſpecially when any thing moves the water. One filled a flaſk with this water; but it emitted no

light

light till it was ſtirred in the dark. When this was ſtrained through a fine cloth, the cloth ſhone in the dark, but not the water. This light conſiſted of innumerable lucid particles. When ſome of this ſea-graſs was taken up, there were above thirty of theſe particles on one leaf, one of which when it was ſhaken, fell off. It was as fine as an eye-laſh and about as long. Viewed with a microſcope it appeared to be a worm or maggot, conſiſting of eleven rings, with as many mamillæ on the ſides inſtead of feet. Their whole bodies were lucid, though leaſt ſo, when at reſt. In ſpring they confine themſelves to the ſea-graſs: but in ſummer they are diſperſed all over the ſea and moſtly on the ſurface. When this ſea ſparkles more than uſual, it is the ſure ſign of a ſtorm: and this proceeds from the greater agitation of the worms, already ſenſible of the approaching change. Hence it is clear, that the glittering of this ſea, in a ſhip's courſe, is occaſioned by theſe worms: which probably is the caſe in ſome other ſeas alſo. And they are certainly the cauſe of the light in the Pinna-Marina, a large muſcle frequently caught by the Algerine fiſhermen.

Many ſea-fiſh indeed have a viſcous matter about their gills, eſpecially when they have been ſome time dead. Theſe, when kept in ſea-water, ſhine as bright as a flaming coal. A ſtick rubbed on their gills, becomes luminous wherever it has touched them, and continues ſo, while it continues moiſt; but as it dries, the light fades.

There is a ſmall ſhell-fiſh, called a Dactylus, which is luminous all over. When it is taken out of the ſhell, in the dark, every part of its ſurface ſhines with a bright light. Nor is it the ſurface only; but the whole body. For if it be wounded either lengthways or acroſs, the out parts are as luminous as the ſurface. It is therefore, a true, natural phoſphorus, and makes every thing luminous that touches it, which remains ſo as long as it is wet. When it is freſh caught it abounds with water, and the very drops which fall from it are luminous.

Some

Some boiled Mackrel having been left in the water for pickle, the cook, a day or two after, ſtirring the water, found it very luminous. Wherever the drops of it fell on the ground they ſhined. The next day we repeated the trial. The water ſtill ſtirred, gave no light; but when gently ſtirred by the hand, it ſhone bright; and by a briſker motion it ſeemed to flame. The fiſh ſhone, as well from the inſide as the out: yet they were not either fetid or inſipid. When fetid they did not ſhine at all.

The chief circumſtance which Mr. B. noted concerning luminous fleſh were, 1. It was a neck of veal, bought ſome days before: 2. In this about twenty places ſhone, though not alike: 3. Moſt of theſe were as big as the nail of a man's finger, and irregularly ſhaped: 4. The parts which ſhone moſt were the griſly, or the bruiſed parts of the bones: 5. Some of theſe were ſo bright, that holding a printed paper to them, I could read ſeveral letters: 6. One could not diſcern in any of them the leaſt degree of heat, neither of putrefaction: 7. One of theſe being put in a cup of cold water, the light continued the ſame.

Not only water, fiſh, and fleſh, but ſome ſort of wood will ſhine as bright as a burning coal. And herein they agree, 1. Both have light in themſelves: 2. Both need the air, to make them continue ſhining: 3. Both having loſt their light, by being deprived of the air, recover it, when freſh air is let in: 4. Both are eaſily quenched by water, 5. Neither of them is affected by the coldneſs of the air.

But herein they differ: 1. The light of a coal is put out by compreſſion: that of wood is not: 2. The coal is quite extinguiſhed by withdrawing the air: that of the wood is only eclipſed: let the air in again within half an hour, and it immediately recovers: A coal put into a ſmall, cloſe glaſs, will not burn many minutes: a piece of wood will ſhine many days: 4. A burning coal emits much ſmoke, ſhining wood none at all.

A diamond, by an eaſy friction in the dark, by the finger or a woollen cloth, appears in its whole body to be luminous: and if it has been rubbed a good while,

while, it will keep its light for a little time. If when the ſun is ſet, one holds up a piece of flannel ſtretched tight between both hands at a little diſtance, and another rubs the diamond ſwiftly and ſtrongly on the other ſide of it, the light to the eye of him that holds the cloth, ſeems much more pleaſant and perfect. What is more ſurpriſing, is, that a diamond expoſed to the open air, in view of the ſky, (even without being in the ſunſhine) gives nearly the ſame light of itſelf without rubbing, as when rubbed in a dark room. But if you hold your hand or any thing elſe over it, to hinder its communication with the ſky, let it lie ever ſo long in the open air, yet it will give no light.

A well-poliſhed piece of amber, will yield light if rubbed in the dark. And if it be drawn ſwiftly through a woollen cloth, very many little cracklings are heard, and each produces a little flaſh of light. If drawn gently it produces a light, but no crackling.

The ſplendor of the ſea-water during the night, hath long been a ſubject of admiration, and upon the coaſts of Chioggia it is particularly remarkable: at firſt ſight one would imagine that the brilliant images of the fixed ſtars were reflected by the ſea, when agitated by the winds. This brightneſs becomes much more vivid and copious, in places abounding with the Alga Marina, or ſea-weed.

One ſummer-night I took a veſſel full of the ſea-water home with me. I placed it in a dark room, and obſerved as often as I diſturbed the water, a very bright light iſſued from it. I then paſſed the water through a very cloſe linen cloth, to try if it would ſtill retain its ſplendor after ſuch percolation. But notwithſtanding I agitated it in the moſt violent manner, I could not excite the leaſt luminouſneſs in it. The linen cloth however afforded the moſt charming ſpectacle imaginable: it was covered with an infinity of lucid particles. To the naked eye they appear ſmaller than the fineſt hairs: their colour of a deep yellow, and their ſubſtance delicate beyond imagination: but having a mind to examine them more curiouſly, I furniſhed myſelf with a good microſcope, and was ſoon convinced that

theſe luminous atoms are really living animals of a very ſingular ſtructure, and from the brightneſs of their luſtre, I thought myſelf authoriſed to name them Marine Glow-Worms.

Theſe little animals, ſimilar to caterpillars, and other inſects of that ſpecies, are compoſed of eleven articulations, or annuli, a number which, according to the celebrated Malpighi, is peculiar to the whole vermicular race. Upon theſe annuli, and near the belly of the animal, are a ſort of ſmall fins or wings, which ſeem to be the inſtruments of its motion. It has two ſmall horns iſſuing from the fore part of its head, and its tail is cleft in two. Their whole body is luminous, and when cut to pieces, every piece emits a vivid light for ſome time; probably ſo long as the concluſive motion of the dying parts continues.

Many philoſophers of the firſt rank have imagined that the luminouſneſs of the ſea-water in the night-ſeaſon is occaſioned by ſome electric matter. "The ſurface of the ſea, ſay they, having been expoſed all the ſummer to the impulſe of the ſolar rays, when it begins to be agitated by the autumnal winds, throws out luminous ſparks perfectly ſimilar to thoſe which iſſue from electrified bodies."

But ocular demonſtration now convinces us, that this brightneſs is frequently, if not always, to be aſcribed to the little animals.

The light of a glow-worm is ſo ſtrong, that it will ſhew itſelf through ſeveral ſubſtances. The creature ſeems dead in the day-time, and its light is not then viſible, even in a dark room, unleſs it be put in motion, and then it is very faint. After ſun-ſet the light begins to return, and with it the life and motion of the animal. Indeed, the motion and light ſeem to depend on each other: it never ſhines, but when it moves: and when it ſhines moſt, the body is one third longer than in the day-time. While it ſhines brighteſt, it ſometimes turns about, and the light is no larger than a pin's head. But on being touched, it immediately extends itſelf, and the light is as large and bright as ever.

The luminous parts are two ſmall ſpecks under the tail. The uſe of its light is, to direct the animal in its courſe,

courſe, and in taking of its prey. It is admirably placed for this purpoſe. The tail is eaſily bent under its belly, and throws its light full upon any object, about or under the head of the animal, and the eyes are placed not on the upper part, but on the under ſide of the head, ſo that they have all the advantages of it, while the light in this part is not offenſive to the eyes, as it naturally would have been, if carried about the head. The creature can upon occaſion cover this light, ſo as not to be known, or purſued by its enemies. It is an inſect of the beetle-kind, of a brown and duſky colour. It has ſhell wings as the other beetles have. Its head is covered with a ſort of broad-brimmed hat, under which are the eyes which are black and large.

Falling ſtars, ſo called, ſeem to be vapours of an unctuous kind, kindled in the lower regions of the air: unleſs this alſo (as many other phænomena of the ſort) be owing to what is vulgarly termed electricity.

10. From a thouſand experiments it appears, that there is a fluid far more ſubtle than air, which is every where diffuſed through all ſpace, which ſurrounds the earth, and pervades every part of it. And ſuch is the extreme fineneſs, velocity, and expanſiveneſs of this active principle, that all other matter ſeems to be only the body, and this the ſoul of the univerſe.

It is highly probable this is the general inſtrument of all the motion in the univerſe: from this pure fire, (which is properly ſo called) the vulgar culinary fire is kindled. For in truth, there is but one kind of fire in nature, which exiſts in all places and in all bodies. And this is ſubtle and active enough, not only to be under the great cauſe, the ſecondary cauſe of motion, but to produce and ſuſtain life throughout all nature, as well in animals as in vegetables.

This great machine of the world, requires ſome ſuch conſtant, active, and powerful principle, conſtituted by its Creator, to keep the heavenly bodies in their ſeveral courſes, and at the ſame time give ſupport, life, and increaſe to the various inhabitants of the earth. Now as the heat of every animal is the engine which circulates the blood through the whole body, ſo the ſun, as

the heart of the world, circulates this fire through the whole univerſe. And this element is not capable of any eſſential alteration, increaſe, or dimunition. It is a ſpecies by itſelf: and is of a nature totally diſtinct from that of all other bodies.

That this is abſolutely neceſſary both to feed common fire, and to ſuſtain the life of animals, may be learned from an eaſy experiment. Place a cat, together with a lighted candle, in a cold oven: then lute the door cloſe, having fixed a glaſs in the middle of it; and if you look through this, you may obſerve at one and the ſame inſtant, the candle goes out, and the animal dies. A plain proof, that the ſame fire is needful to ſuſtain both culinary fire and animal life: and a large quantity of it. Some doubtleſs pervades the oven-door; but not enough to ſuſtain either flame or life. Indeed, every animal is a kind of fire-engine. As ſoon as the lungs inſpire the air, the fire mingled with it is inſtantly diſperſed through the pulmonary veſſels into the blood: thence it is diffuſed through every part of the body, even the moſt minute arteries, veins and nerves. In the mean time the lungs inſpire more air and fire, and ſo provide a conſtant ſupply.

The air ſeems to be univerſally impregnated with this fire, but ſo diluted, as not to hurt the animal in reſpiration. So a ſmall quantity of a liquor dropt in water may be friendly to a human body, though a few drops of the ſame liquor given by themſelves, would have occaſioned certain death. And yet you cannot conceive one particle of the water, without a particle of the medicine. It is not impoſſible, this may be one great uſe of air, by adhering ſo cloſely to the elementary fire, to temper and render ſalutary to the body, what would otherwiſe be fatal to it.

To put it beyond diſpute, that this fire is largely mixed with the air, you may make the following experiment. Take a round lump of iron, and heat it to a degree called a welding heat: take it out of the fire, and with a pair of bellows, blow cold air upon it. The iron will then as effectually melt, as if it were in the hotteſt fire. Now when taken out of the forge, it had not fire enough in it to conquer the coheſion of its parts:

parts: but when this fire is joined with that which was mixed with the air, it is ſufficient to do it. On the ſame principle we account for the increaſe of a coal or wood fire, by blowing it.

And let none wonder, that fire ſhould be ſo connected with air, as hardly to be ſeparated. As ſubtle as fire is, we may even by art attach it to other bodies; yea, and keep it priſoner for many years; and that, either in a ſolid or fluid form. An inſtance of the firſt we have in ſteel; which is made ſuch, only by impacting a large quantity of fire into bars of iron. In like manner, we impact a great quantity of fire into ſtone to make lime. An inſtance of the ſecond kind we have in ſpirits, wherein fire is impriſoned in a fluid form. Hence common ſpirits will burn all away. And if you throw into the air, ſpirits rectified to the higheſt degree, not one drop will come down again, but the univerſal fire will take hold of and abſorb it all.

That this fire ſubſiſts both in air, earth, and water: that it is diffuſed through all and every part of the univerſe, was ſuſpected by many of the ancient naturaliſts, and believed by the great Sir Iſaac Newton. But of late years it has been fully demonſtrated: particularly by Mr. Stephen Gray, a penſioner at the Charterhouſe: who ſome years ſince preſented to the Royal Society, an account of many experiments he had made, whereby this ſubtle fluid became clearly perceptible both to the ſight and feeling. Becauſe the glaſs tube, by means of which thoſe experiments were made, was obſerved when rubbed to attract ſtraws and other light bodies (a known property of amber, called in Latin electrum) theſe experiments were termed electrical; a word which was ſoon affixed to that ſubtle fluid itſelf, and every thing pertaining to it. But improperly enough: ſeeing the attracting (or ſeeming to attract) ſtraws and feathers, is one of the moſt inconſiderable of all the effects, wrought by this powerful and univerſal cauſe.

It was afterwards found, that a glaſs globe was preferable to a glaſs tube. A greater quantity of ethe-

real fire is collected by this means, than by the other. I say, collected; for that fire is no more created by rubbing, than water is by pumping. The grand reservoir thereof is the earth, from which it is diffused every way. Accordingly in these experiments, the globe rubbing against the cushion, collects fire from it. The cushion receives it from the frame of the machine; the frame of the machine from the floor. But if you cut off the communication with the floor, far less fire can be produced, because less is collected.

Many new discoveries have been made by means of a large, but thin glass phial. This phial is hung on any metallic body, which communicates by a wire, with the globe. This metallic body has been termed the prime conductor, as it conducts or conveys the fire, collected by the globe, either into the phial, or into any other body communicating therewith.

But all bodies are not capable of receiving it. There is in this respect an amazing difference between them. The excrements of nature, as wax, silk, hair, will not receive the ethereal fire, neither convey it to other bodies: so that, whenever in circulating it comes to any of these, it is at a full stop. Air itself is a body of this kind; with great difficulty either receiving or conveying this fire to other bodies: so are pitch and rosin (excrements, as it were, of trees.) To these we may add glass, amber, brimstone, dry earth, and a few other bodies. These have been frequently stiled electrics per se; as if they alone contained the electric fire: an eminently improper title, founded on a palpable mistake. From the same mistake, all other bodies, which easily receive and readily convey it, were termed non-electrics; on a supposition, that they contained no electric fire: the contrary of which is now allowed by all.

That this fire is inconceivably subtle, appears from its permeating even in the densest metals, and that with such ease, as to receive no perceptible resistance. If any one doubt, whether it pass, through the substance, or only along the surface of bodies, a strong shock ta-

ken

ken through his own body, will prevent his doubting any longer. It differs from all other matter in this, that the particles of it repel, not attract each other. And hence is the manifeſt divergency in a ſtream of electrical effluvia. But though the particles of it repel each other, yet are they attracted by all other matter. And from theſe three, the extreme ſubtlety of this fire, the mutual repulſion of its parts, and the ſtrong attraction of them by other matter, ariſes this effect, that if any quantity of electric fire be applied to a maſs of common matter of any bigneſs or length, (which has not already got its quantity) it is immediately diffuſed through the whole.

It ſeems this globe of earth and water, with its plants, animals, buildings, have, diffuſed through their whole ſubſtance, juſt as much of this fire as they will contain. And this we may term their natural quantity. This is not the ſame in all kinds of matter: neither in the ſame kind of matter, in all circumſtances. A ſolid foot of one kind of matter (as glaſs) contains more of it than a ſolid foot of another kind. And a pound weight of the ſame kind of matter, when rarefied, contains more than it did before.

We know that this fire is in common matter, becauſe we can pump it out by the globe: we know that common matter has near as much of it as it can contain, becauſe if we add a little more to any portion of it, the additional quantity does not enter, but forms a kind of atmoſphere round it. On the other hand we know, that common matter has not more of it than it can contain. Otherwiſe all looſe portions of it would repel each other; as they conſtantly do, when they have ſuch atmoſpheres. Had the earth, for inſtance, as much electric fire in proportion, as we can give to a globe of iron or wood, the particles of duſt and other light matter would not only repel each other, but be continually repelled from the earth. Hence the air, being conſtantly loaded therewith would be unfit for reſpiration. Here we ſee another occaſion to adore that wiſdom, which has made all things by weight and meaſure.

The

The form of every electric atmoſphere, is that of the body which it ſurrounds: becauſe it is attracted by every part of the ſurface, though it cannot enter the ſubſtance already replete. Without this attraction, it would not remain round the body, but diſſipate into the air.

The atmoſphere of an electrified ſphere, is not more equally drawn off from any one part of it than from another, becauſe it is eaſily attracted by every part. But it is not ſo with bodies of other figures. From a cube it is more eaſily drawn off at the corners than at the ſides: and ſo from the corners of bodies of any other form, and moſt eaſily from the ſharpeſt corners. For the force with which an electrified body retains its atmoſphere, is proportioned to the ſurface on which that atmoſphere reſts. So a ſurface four inches ſquare retains its atmoſphere, with ſixteen times the force that one of an inch ſquare does. And as in pulling the hairs from a horſe's tail, a force inſufficient to pull off a handful at once, could eaſily pull it off hair by hair: ſo though a blunt body cannot draw off all the atmoſphere at once, a pointed one can eaſily draw it off, particle by particle.

While the electric fire, which is in all bodies, is left to itſelf, undiſturbed by any external violence, it is more or leſs denſe, according to the nature of the body which it is in. In denſe bodies it is more rare: in rare bodies it is more denſe. Accordingly every body contains ſuch a quantity of it, rare, or denſe, as is ſuitable to its nature. And there is ſome reſiſtance to every endeavour of altering its denſity, in the whole of any body, or in any part of it. For all bodies reſiſt either the increaſe or diminution of their natural quantity. And on the other hand, when it has been either increaſed or diminiſhed, there is a reſiſtance to its return to its natural ſtate.

With regard to the different reſiſtance made by different bodies, in either of theſe caſes, it is an invariable rule, that glaſs, wax, roſin, brimſtone, ſilk, hair, and ſuch like bodies, reſiſt the moſt: and next to theſe, the air, provided it be dry, and in a ſufficient quantity. That this reſiſtance is leaſt in metals, minerals,

nerals, water, animals, and vegetables, which we may rank together, becauſe the difference in their reſiſtance is very inconſiderable : and that in theſe bodies the reſiſtance is greater, when their ſurfaces are poliſhed, and extended in length, than when their ſurfaces are rough and ſhort, or end in ſharp points.

When a body has more electric fire forced into it, than it has naturally, it is ſaid to be electrified poſitively. When part of the natural quantity is taken away, it is ſaid to be electrified negatively. Now when an iron bar is negatively electrified, the fire drawn out does not go in again as ſoon as the experiment is over, but forms an atmoſphere round it, becauſe of the reſiſtance it finds in its endeavour to dilate itſelf, either into the air, or into the bar. And when it is electrified poſitively, the ſame kind of atmoſphere is formed, by the fire accumulated upon it. Whether therefore bodies are electrified negatively or poſitively, and remain ſo when the experiment is over, there are ſimilar atmoſpheres ſurrounding them, which will produce ſimilar effects.

But we can electrify no body beyond a certain degree ; becauſe when any is electrified to that point, it has an atmoſphere round it, ſufficiently ſtrong to balance any power that endeavours to electrify it farther.

And in the ordinary courſe of nature, this ſubtle, active fluid, which not only ſurrounds every groſs body, but every component particle of each, where it is not in abſolute contact with its neighbouring particle, can never be idle, but is ever in action, though that action be imperceptible to our ſenſes. It is ever varying its condition, though imperceptibly, in all parts of all bodies whatever ; and electrifying them more or leſs, though not ſo forcibly as to give ſenſible ſigns of it. All bodies then, and all their component particles, when in their natural ſituation, have round their ſurfaces, where they are not in abſolute contact with other ſurfaces, an imperceptible atmoſphere, ſufficient to balance the ſmaller force with which they are attacked : every way ſimilar to the perceptible atmoſphere of bodies

dies forcibly electrified. In theſe imperceptible atmoſpheres is placed the power which reſiſts their being electrified to an higher degree than they are naturally. And this power lies in the elaſticity of the ſubtle fluid, every where diſperſed both round all bodies and in them.

Glaſs is very difficultly electrified, which ſeems to prove it has a very denſe electric atmoſphere. Metals are eaſily electrified. Conſequently they have rare, and therefore weakly reſiſting atmoſpheres. But as heat rarefies all bodies, ſo if glaſs be heated to a certain degree, even below melting it will give as free a paſſage to the electric fire, as braſs or iron does: the atmoſphere round it being then rendered as rare as that of metals. Nay, when melted, it makes no more reſiſtance than water. But its reſiſtance increaſes, as it cools. And when it is quite cold, it reſiſts as forcibly as ever. Smoothly-poliſhed wax, reſiſts as much as glaſs. But even the ſmall heat raiſed by rubbing, will render its atmoſphere as rare as that of metals, and ſo entirely deſtroy its reſiſtance. The ſame is true of roſin and brimſtone. Even the heat ariſing from friction, deſtroys the reſiſtance which they naturally make to being electrified: a ſtrong proof, that the reſiſtance of all bodies thereto, is exerted at their ſurfaces, and cauſed by an electric atmoſphere of different denſities, according to their different circumſtances.

Moſt experiments will ſucceed as well with a globe of brimſtone, as with one of glaſs. Yet there is a conſiderable difference in their nature. What glaſs repels, brimſtone (as alſo roſin) attracts. Rubbed glaſs emits the electric fire: rubbed brimſtone, roſin and wax receive it. Hence if a glaſs globe be turned at one end of a prime conductor, and a brimſtone one at the other, not a ſpark of fire can be obtained; one receiving it in, as faſt as it is given out by the other. Hence alſo if a phial be ſuſpended on the prime conductor, with a chain from its coating to the table, and only one globe turned, it will be electrified (or charged as they term it) by twenty turns of the wheel: after which it may

be

be diſcharged, that is unelectrified, by twenty turns of the other wheel.

The difference between non electrics (vulgarly ſpeaking) and electrics per ſe, is chiefly this. 1. A non electric eaſily ſuffers a change, in the quantity of fire it contains. Its whole quantity may be leſſened, by drawing out a part, which it will afterwards reſume. But you can only leſſen the quantity contained in one of the ſurfaces of an electric : and not that, but by adding at the ſame time an equal quantity to the other ſurface. So that the whole glaſs will always have the ſame quantity in its two ſurfaces. And even this can be only done in glaſs that is thin : beyond a certain thickneſs, we know no power that can make this change. 2. The ethereal fire freely moves from place to place, in and through the ſubſtance of a non-electric, but through the ſubſtance of an electric it will by no means paſs. It freely enters an iron rod, and moves from one end to another, where the overplus is diſcharged. But it will not enter, or move through a glaſs rod. Neither will the thinneſt glaſs which can be made, ſuffer any particle of it entering one of its ſurfaces, to paſs through to the other.

Indeed it is only metals and liquids, that perfectly conduct (or tranſmit this fire. Other bodies ſeem to conduct it, only ſo far as they contain a mixture of theſe ; accordingly, moiſt air will conduct it in proportion to its moiſtneſs. But dry air will not conduct it at all : on the contrary, it is the main inſtrument, in confining any electric atmoſphere to the body which it ſurrounds. Dry air prevents it diſſipating (which it does preſently when in vacuo) or paſſing from body to body. A clear bottle full of air, inſtead of water, cannot be electrified. But exhauſted of air, it is electrified as effectually as if it was full of water. Yet an electrical atmoſphere and air, do not exclude one another. For we breathe in it freely, and dry air will blow through it, without altering it at all.

When a glaſs phial is electrified, whatever quantity of fire is accumulated on the inner ſurface, an equal

quantity is taken from the outer. Suppoſe, before the operation begins, the quantity of fire contained in each ſurface, is equal to twenty grains: ſuppoſe at every turn of the globe, one grain is thrown in: then after the firſt ſtroke there are twenty-one within, nineteen only without: after the ſecond, the inner ſurface will have twenty-two, the outer but eighteen: and ſo on, till after twenty ſtrokes, the inner will have forty, the outer none. And the operation ends: for no power or art of man can throw any more on the inner ſurface, when no more can be taken from the outer. If you attempt to throw more in, it is thrown back through the wire, or flies out in cracks, through the ſides of the phial. The equilibrium cannot be reſtored in this phial, but by a communication formed between the inner and outer ſurface, by ſomething external, touching both the outer, and the wire, which communicates with the inner ſurface. If you touch theſe by turns, it is reſtored by degrees: if both at once, it is reſtored inſtantly. But then there is a ſhock occaſioned by the ſudden paſſing of the fire through the body, in its way from the inner to the outer ſurface. For it moves from the wire to the finger, (not from the finger to the wire, as is commonly ſuppoſed.) Thence it paſſes through the body to the other hand, and ſo to the outer ſurface.

The force with which this ſhock may be given, is far greater than one would conceive. It will kiil rats, hens, or even turkeys in a moment: others that are not quite killed, it ſtrikes blind. It will give polarity to a fine needle, making it point north and ſouth, as if touched by a loadſtone. It will invert the polarity of a compaſs, and make the north point turn to the ſouth. At the ſame time the ends of the needles are finely blued, like the ſpring of a watch. It will melt off the heads and points of pins and needles, and ſometimes the whole ſurface of the needle is run, and appears, as it were, bliſtered, when examined by a magnifying glaſs. It will melt thin gold or ſilver, when held tight between two panes of glaſs, together with the ſurface of the glaſs itſelf, and incorporate them in a fine enamel. Yea, a ſtrong ſpark from an electrified phial makes a fair hole through a quire of paper doubled:

which

which is thought good armour againſt the puſh of a ſword, or even a piſtol bullet. And it is amazing to obſerve in how ſmall a portion of glaſs, a great electrical force may be. A thin glaſs bubble, about an inch diameter, being half filled with water, partly gilt on the outſide, when electrified gives as ſtrong a ſhock, as a man can well bear: allowing then that it contains no more fire after charging than before, how much fire muſt there be in the ſmall glaſs? It ſeems to be a part of its very ſubſtance. Perhaps if that fire could be ſeparated from it, it would be no longer glaſs. It might in loſing this, loſe its moſt eſſential property, its tranſparency, brittleneſs, and elaſticity.

Some have not improbably ſuppoſed, that all electric bodies, ſo called, are by their original conſtitution, thoroughly ſaturated with electric fire: that it remains fixed in them, (unleſs while the texture of thoſe bodies is quite altered by liquefaction) that fire fixed in a body conſtitutes an electric, and all bodies where it is not fixed are non electrics. Agreeably to which they ſuppoſe, that in all non electrics, the original fire looſely inhering, is eaſily driven on by the new collected fire, which then poſſeſſes its place: but that in electrics, the original fire being impacted into their ſubſtance, and therefore more firmly inhering, will not give way to, or be driven on by, the new collected fire. Such is air in particular; with the particles of which the original fire is cloſely incorporated. Dry air ſeems to be ſo fully ſaturated with it, that it is ſcarce capable of receiving any more: whereas all new-collected fire is contiuually endeavouring to return into the earth. Let wires be electrified ever ſo ſtrongly, yet the moment any part of them is touched by a perſon ſtanding on the floor, they are electrified no longer; all the fire eſcaping through him into the earth.

Upon the principles of electricity, we may give a more rational account of many appearances in nature, than has yet been done: of thunder and lightning in particular. In order to which we may obſerve, all electrified bodies retain the fire thrown into them, till ſome non-electric approaches: to which it is then communicated

nicated with a ſnap, and becomes equally divided. Electric fire is ſtrongly attracted by water, and readily mixes with it. And water being electrified, the vapours ariſing from it, are equally electrified. As theſe float in the air, they retain the additional fire, till they meet with clouds, not ſo much electrified. Then they communicate it with a ſhock.

The ocean is compounded of water and ſalt; one an electric the other not. When there is a friction among the parts near its ſurface, the fire is collected from the parts below. It is then plainly viſible in the night, at the ſtern of every ſailing veſſel. It appears from every daſh of an oar: in ſtorms the whole ſea ſeems on fire. The particles of water then repelled from the electrified ſurface, continually carry off the fire as it is collected. They riſe and form clouds which are highly electrified, and retain the fire, till they have an opportunity of diſcharging it.

Particles of water riſing in vapours, attach themſelves to particles of air. One particle of air may be ſurrounded by twelve particles of water as large as itſelf, all touching it, and by more added to them. Particles of air thus loaded would be drawn nearer together by the mutual attraction of the particles of water, did not the fire, common or electric, included therein, aſſiſt their mutual repulſion. Hence they continue ſuſpended. But if air thus loaded, be compreſſed by adverſe winds, or by being driven againſt mountains, or if it be condenſed by the loſs of its fire, it will continue ſuſpended no longer, but will deſcend in dew. And if the water ſurrounding one particle of air comes into contact with that ſurrounding another, they naturally coaleſce into a drop, and ſo deſcend in rain.

The Sun ſupplies common fire to all vapours riſing either from ſea or land. Vapours having both this and electric fire, are better ſupported than thoſe which have this only. For when vapours riſe into the coldeſt region, the common fire may fail. But the cold will not diminiſh the electric: this is always the ſame. Hence clouds raiſed from freſh waters, from moiſt earth,

earth, or growing vegetables, more eaſily deſcend and depoſit their waters, as having but little electric fire, as to keep the particles ſeparate from each other. So that the greateſt part of the water raiſed from the land, falls on the land again. But clouds raiſed from the ſea, having both fires, and much of the electric, ſupport their water far more ſtrongly, and being aſſiſted by winds, may bring it from the middle of the wideſt ocean to the middle of the broadeſt continent. And yet a way is provided whereby theſe alſo are readily brought to depoſit their water. For whenever they are driven againſt mountains by the winds, thoſe mountains take away their electric fire; and, being cold, the common alſo: hence the particles immediately cloſe. If the air is not much loaded, the water falls in a dew on the top and the ſides of the mountain. If it is, the electric fire being taken at once from the whole cloud, it flaſhes brightly, and cracks loudly. And the particles inſtantly coaleſcing for want of that fire, fall in a heavy ſhower.

When a ridge of mountains ſtops the clouds, and draws the electric fire from the cloud firſt approaching it; the next, when it comes near the firſt, now deprived of its fire, flaſhes into it, and depoſits its own water. The third cloud approaching, and all that ſucceed, act in the ſame manner, as far back as they extend, which may be for ſeveral hundred miles. Hence the continual ſtorms of thunder, lightning, and rain, on the eaſt ſide of thoſe vaſt mountains, the Andes, which, running north and ſouth, intercept all the clouds brought againſt them from the Atlantic ocean. In a plain country, there are other means to make them drop their water. For if an electrified cloud, coming from the ſea, meets in the air a cloud coming from the land, and therefore not electrified, the firſt will give its flaſh into the latter, and thereby both will be made to depoſit their water. The concuſſion of the air contributes alſo to ſhake down the water, not only from thoſe two clouds, but from others near them. When the ſea and land clouds would paſs at too great a diſtance from each other, they are mutually attracted, till within the diſtance. For the ſphere of electrical

attraction

attraction is far beyond the flaſhing diſtance. And yet where a cloud contains much fire, it may ſtrike at a conſiderable diſtance. When a conductor has but little fire in it, you muſt approach very near before you can draw a ſpark. Throw into it a greater quantity of fire, and it will give a ſpark at a greater diſtance. But if a gun barrel, when electrified, will ſtrike and make a noiſe at the diſtance of an inch, at what a diſtance, and with how great a noiſe, may ten thouſand acres of electrified cloud ſtrike? No wonder that this ſhould melt metals, (which our artificial flaſh does in ſome degree,) though perhaps not ſo properly by its heat, as by inſinuating into the pores, and creating a violent repulſion between the particles of the metal it paſſes through. This overcomes the attraction whereby they cohere, and ſo melts the metallic body. And this accounts for its melting a ſword in the ſcabbard, or gold in the pocket, without burning either.

But thunder-clouds do not always contain more than their natural quantity of electric fire. Very frequently they contain leſs. And when this is the caſe, when they are negatively electrified, although the effects and appearances are nearly the ſame, yet the manner of operation is different. For in this caſe, it is really the fire from the mountains, or other parts of the earth, which ſtrikes into the cloud; and not as we imagine, fire from the cloud which ſtrikes into the earth. And we may eaſily conceive, how a cloud may be negatively electrified. When a portion of water is rarefied into a thin vapour, the fire it contains is rarefied too. Conſequently it has then leſs than its natural quantity of fire. Such a cloud therefore coming within a due diſtance of the earth, will receive from it a flaſh of electric fire; which flaſh, to ſupply a great extent of cloud, muſt often contain a great quantity of fire. Such a cloud alſo paſſing over woods of tall trees, may ſilently receive ſome ſupply, either from the points of the boughs, or from the ſharpeſt ends and edges of the leaves. The cloud thus ſupplied, flaſhes into other clouds that have not been ſo ſupplied; and thoſe into others, till an equilibrium is produced, among all that are within a ſtriking diſtance of each other. And hence are repeated ſtrokes and flaſhes, till they deſcend in ſhowers

to the earth, their original. Rain, eſpecially when in large drops, generally brings down the electric fire: falling ſnow, often: ſummer hail, always, though ſilently. Conſequently any of theſe may prevent thunder and lightning; or, at leaſt abate its violence. Rain is helpful in another reſpect likewiſe. By wetting men or beaſts, it ſaves many lives. For if your clothes are thoroughly wet, and a flaſh of lightning ſtrikes the top of your head, it will run in the water over the ſurface of your body into the ground: whereas if your clothes were not wet, it would go through your body. Hence a wet chicken cannot be killed by a ſtroke from the phial: whereas a dry one is killed in an inſtant. See here alſo the wiſdom and goodneſs of Him, "who ſendeth forth lightning with the rain!" It ſhould likewiſe be obſerved, that wherever electrified clouds paſs, ſpires, towers, chimnies, and high trees, as ſo many points draw the electric fire, and the whole cloud frequently diſcharges there. Therefore it is highly dangerous in ſuch a ſtorm, to take ſhelter under a tree.

Common fire is more or leſs in all bodies, as well as electrical. If there be a ſufficient quantity of either in any body, it is inflamed. But when the quantity of common fire therein is ſmall, there needs more electric fire to enflame it. Where the quantity of common fire is greater, leſs of the electric will ſuffice. So if ſpirits are heated, a ſmall ſpark inflames them. If they are not, the ſpark muſt be greater. Sulphureous vapours, whether riſing from the earth, or from ſtacks of moiſt hay or corn, or any other heated and reeking vegetable, contain abundance of common fire. A ſmall addition of electric then will enflame them. Therefore they are eaſily kindled by lightning.

Any who would be clearly convinced of the nature of lightning, may make the following experiment. Make a ſmall croſs of two thin ſtrips of wood, the arms being juſt ſo long as to reach the four corners of a large, thin ſilk handkerchief when extended. Tie the corners of this to the extremities of the croſs; and ſo you have the body of a kite: add to this a proper tail, loop, and ſtring, and it will riſe in the air like one made

made with paper: but this is fitter to bear the wind and wet in a ſtorm without tearing. To the top of the croſs fix a ſharp-pointed wire, riſing a foot above it. Tie a ſilk ribbon to the end of the twine next the hand: and where the ſilk and twine join, faſten a key. Raiſe this kite when a thunder-ſtorm is coming on. But he that holds the ſtring, muſt ſtand in a porch, or under ſome other covering, that the ribbon may not be wet. He muſt likewiſe take particular care, that the twine do not touch the top or ſide of the porch. As ſoon as the thunder-cloud comes over the kite, the pointed wire draws the electric fire from it. The kite and all the twine are then electrified, as plainly appears by this, that the looſe filaments of the twine ſtand out every way, and are attracted by an approaching finger. And when the kite and twine being wet, conduct the fire freely, it will ſtream from the key, on the approach of the knuckle. By this key the phial may be charged, and all other experiments made, as by the globe. And this is a demonſtration, that the electric fire thereby obtained, is the very ſame with that of lightning.

Another proof of this we have, in the remarkable caſe of the Rev. Mr. Winder, rector of Halſtead in Eſſex: who at the age of 54 was a ſtranger to diſeaſe: nay, almoſt unacquainted with pain of any kind. But on June 3, 1761, he began to falter in his ſpeech. He did not regard it, till on July 1, he ſuddenly fell from his chair, by a ſtroke of the palſy. When a little recovered, he was almoſt wholly deprived of ſpeech, and in a great meaſure of his ſenſes. But by proper medicines he was in a few weeks ſo far reſtored, as to walk a little by the help of a cane. In other reſpects he was as before, till in June 1762, he was removed to Tunbridge. After drinking the waters ſix weeks, he was much relieved; but an univerſal weakneſs ſtill remained. He had alſo violent palpitations of the heart, trembling of the limbs, ſubſultutendinum; with frequent vertigos. Worſe than all was, a conſtant pain fixed deep in his breaſt, with an extreme dejection of ſpirit. Thus he continued till the 24th of Auguſt:

Auguſt: when about ten at night, while he was aſleep in bed, it began to thunder and lighten violently. The noiſe ſuddenly awakened him. At the inſtant he felt a quick, ſtrong ſhock, affecting him all over, juſt like an electric ſhock. At the ſame time the chamber was filled with lightning, which left behind it a ſtrong phoſphorous ſmell. Immediately he felt as if ſome obſtruction in his cheſt was ſuddenly removed: and his breaſt recovered its full liberty and expanſion, the oppreſſion being entirely gone. When he aroſe in the morning he was in perfect health: his head was quite ſerene: his breaſt eaſy, and he could move all his limbs with as much ſteadineſs and agility as ever. Every paralytic ſymptom was gone. He could have walked ten or twelve miles with eaſe. And from that very hour he has continued in a ſtate of perfect health.

What a clear proof this, that the fire of lightning has the ſame nature and force with the electric?

The gymnotus, of South America, appears to poſſeſs electrical powers greatly ſuperior to thoſe of the european torpedo. Some of them have been ſeen in the Surinam river upwards of twenty feet long, whoſe ſtroke was inſtantly fatal. That on which the following experiment was made, was three feet ſeven inches long, and was brought from Guinea to Philadelphia.

On putting a ſmall fiſh into the veſſel in which it ſwam, it was ſuddenly ſtunned and killed by it. The effect was evidently produced by a concuſſion, which was felt by one whoſe fingers were dipped in the water, at the very moment the fiſh was ſhocked by it. Eight or ten perſons, forming a circle, were all ſhocked by it, when the firſt in the ſeries touched the eel, and the laſt put his hand into the water. The commotion given by it, was conveyed through the ſame metallic or other conductors, as convey the electric fluid; and was intercepted by the common non-conductors of that fluid. Whatever therefore be thought of the torpedo, it is plain this eel is an electric machine, and has the power of ſuſpending or giving the electric ſhock, juſt at its own pleaſure.

Electricity has ſomething in it common, both with light and with magnetiſm. In common with magnetiſm it counteracts, and in light ſubſtances overcomes the force of gravity. Like that, it exerts its force in vacuo, as powerfully as in the open air. And this force extends to a conſiderable diſtance, through various ſubſtances of different textures and denſities.

In common with light, electricity pervades glaſs; but it ſuffers no refraction. Its direction is ſtill in right lines, and that through glaſſes of different forms, included one within the other, and large ſpaces between them.

Indeed the electric attraction through glaſs, is much more powerful, when the glaſs is made warm: becauſe warm glaſs does not condenſe the water from the air, which makes the glaſs a conductor of electricity: and alſo becauſe as heat enlarges the dimenſions of all known bodies, and conſequently makes their conſtituent parts recede from each other, the electric effluvia find a more eaſy paſſage through the pores.

And electricity in common with light, when its forces are collected, produces fire and flame.

That the electric matter is far more ſubtle than air, appears, from its paſſing through thoſe bodies which air cannot penetrate; glaſs in particular. And that it is elaſtic, appears from its increaſing the motion of fluids, and from its extending itſelf to a conſiderable diſtance round excited bodies.

Do not all theſe experiments ſhew, that the electric matter is pure elementary fire, an original diſtinct principle, formed by the Creator himſelf? And not as ſome have apprehended, mechanically producible from other bodies?

And may it not be doubted whether this be not the only elaſtic body in the univerſe? Whether it be not the original ſpring, which communicates elaſticity to all other elaſtic bodies? To the air in particular: which is elaſtic no longer, when detached from electric fire, but commences fixed and unelaſtic: and ſeems to recover its elaſticity, only by recovering that ethereal fire which had been violently ſeparated from it?

Scarce any phænomenon in nature has been eſteemed more

more difficult to be accounted for, than thoſe luminous appearances in they ſky, termed Aurora Borealis, or northern lights. But theſe alſo may be rationally explained upon the principles of electricity. We often ſee clouds at different heights, paſſing different ways, north and ſouth at the ſame time. This manifeſtly proves different currents of air, one of them under the other. Now as the air between the tropics is rarefied by the ſun, it riſes: the denſer air is preſſed into its place. The air ſo raiſed moves north and ſouth, and if it has no opportunity before, muſt deſcend in the polar regions. When this air with its vapours deſcends into contact with the vapours ariſing there, the electric fire which it brought begins to be communicated, and is ſeen in clear nights; being firſt viſible where it is firſt in motion, namely in the moſt northern parts. But from thence the ſtreams of light ſeem to ſhoot ſoutherly, even to the zenith of northern countries.

To the ſame principle we may refer what ſome term St. Helmo's fire, and the antient's Caſtor and Pollux, a thin, ſhining light, which is ſometimes ſeen dancing on the decks or rigging of ſhips. A very remarkable account of this, is given by a late author. "In the night it became exceeding dark, and thundered and lightned dreadfully. We ſaw mean time on different parts of the ſhip, above thirty St. Helmo's fires. One which was on the top of the vane of the main-maſt, was more than a foot and a half in length. I ordered one of the ſailors to take down the vane: the noiſe of the fire reſembled that of fired wet gunpowder. Scarce had he lowered the vane, but the fire left it, and fixed on the top of the main-maſt. After remaining there a conſiderable time, it went out by little and little.

"How immenſe a quantity of electric matter muſt have been at that time in the atmoſphere ſurrounding the ſhip, to furniſh more than thirty St. Helmo's fires, (the ſame we ſee at the end of our conductors in electrifying) one of which was above a foot and a half long? The maſts, yards, and every part of the ſhip were then real conductors of the electric fire between the atmoſphere and the ſea, and by that means preſerved the ſhip."

A perſon

A perſon electrified acquires a flammific power, ſtrong enough to light with one of his fingers, or with his cane, warm brandy. When the finger draws near, a cracking ſparkle iſſues out, and ſets it on fire.

The electric ſparks of iron are of a ſilver white, thoſe of braſs, green, and thoſe drawn from an egg, yellowiſh. This ſeems to prove, that the electric matter iſſuing from a body, is ſaturated with ſome parts peculiar to it.

Electricity quickens almoſt all ſorts of motion, that of water in particular, which then glitters in the dark, the fire appearing intermingled with the water. It accelerates the motion of the human blood, quickening the pulſe to fifteen or ſixteen ſtrokes in a minute. The blood that flows from the vein of one electrified, gliſters, ſeparates into ſmall drops, and ſpouts out conſiderably farther than otherwiſe it would do.

It exceedingly haſtens the vegetation of plants. Myrtle trees, which were electrified, budded much ſooner than others of the ſame kind and bigneſs, in the ſame green-houſe. And ſeeds electrified daily have ſhot up and grown more in three or four days, than others of the ſame kind, and alike in all other circumſtances, have done in eleven or twelve.

It cures abundance of diſeaſes, even the moſt ſtubborn; particularly thoſe of the nervous kind; many of them in a moment, by a ſingle touch; moſt, in a few days. So that this is not only one of the greateſt curioſities in the world, but one of the nobleſt medicines that God ever gave to man.

Another phænomenon, which could never before be accounted for, is undoubtedly owing to this cauſe, the ſparkling obſerved on new flannel, when it is rubbed in the dark. Very probably the acid ſteams of ſulphur, which is burnt under the flannel when it is bleached, unite with the oil wherewith hair always abounds, and ſo form an animal ſulphur, which upon any ſtrong agitation of theſe hairs, will become luminous. This ſparkling is moſt obſervable in froſty weather, as electricity is always ſtrongeſt at that time. Flannel loſes this

this property when it is waſhed, the lixivial ſalts of the ſoap, deſtroying the ſulphureous acid, and likewiſe diſcharging its native acid. The wearing flannel, even without its being waſhed, will have the ſame effect: as the effluvia which go off in perſpiration, diſſolve the ſulphur, and weaken the ſpring of the air.

A gentleman has lately made ſome curious experiments on the electricity of hair. A lady had told him, that on combing her hair in froſty weather, in the dark, ſhe had ſometimes obſerved ſparks of fire to iſſue from it. This made him think of attempting to collect the electrical fire from hair alone, without the aſſiſtance of any other electrical apparatus. To this end he deſired a young lady to ſtand on a caſe of bees-wax, and to comb her ſiſter's hair, who was ſitting on a chair before her. Soon after ſhe began to comb, the young lady on the wax was greatly aſtoniſhed to find her whole body electrified, darting out ſparks of fire againſt every object that approached her. The hair was extremely electrified and affected an electrometer, at a very great diſtance. He charged a metal conductor from it with great eaſe; and in the ſpace of a few minutes collected as much fire from her hair as to kindle common ſpirits; and by means of a ſmall phial, gave many ſmart ſhocks to all the company.

Electricity will probably ſoon be conſidered as the great vivifying principle of nature, by which ſhe carries on moſt of her operations. It is a fifth element, diſtinct from, and of a ſuperior nature to the other four, which only compoſe the corporeal parts of matter: but this ſubtle and active fluid is a kind of ſoul that pervades and quickens every particle of it. When an equal quantity of this is diffuſed through the air, and over the face of the earth, every thing continues calm and quiet; but if by any accident one part of matter has acquired a greater quantity than another, the moſt dreadful conſequences often enſue before the equilibrium can be reſtored. Nature ſeems to fall into convulſions, and many of her works are deſtroyed; all the great phænomena are produced; thundering lightning, earthquake, and whirlwinds; for there is

now

now little doubt, that all theſe frequently depend on this ſole cauſe. And again, if we look down from the ſublime of nature to its minutiæ, we ſhall ſtill find the ſame power acting, though perhaps in leſs legible characters; for as the knowledge of its operations, is ſtill in its infancy, they are generally miſunderſtood, or aſcribed to ſome other cauſe. But doubtleſs in proceſs of time theſe will be properly inveſtigated; when men will wonder, how much they have been in the dark. It will then poſſibly be found, that what we call ſenſibility of nerves, and many of thoſe diſeaſes known only by name, are owing to the body's being poſſeſſed of too large or too ſmall a quantity of this ſubtle and active fluid; that very fluid perhaps, that is the vehicle of all our feelings; and which has been ſo long ſearched for in vain in the nerves.

We all know that in damp and hazy weather, when it ſeems to be blunted, and abſorbed by the humidity; when its activity is loſt, and little or none of it can be collected, our ſpirits are more languid, and our ſenſibility leſs acute. And in the wind at Naples, when the air ſeems totally deprived of it, the whole ſyſtem is unſtrung, and the nerves ſeem to loſe both their tenſion and elaſticity, till the north or weſt wind awakens the activity of this animating power; that ſoon reſtores the tone, and enlivens all nature, which ſeemed to droop and languiſh during its abſence.

It is likewiſe well known, that there have been inſtances of the human body becoming electric without the mediation of any electric ſubſtance: and even emitting ſparks of fire with a diſagreeable ſenſation, and an extreme degree of nervous ſenſibility.

About eight or nine years ago, a lady of Switzerland was affected in this manner. She was uncommonle ſenſible of every change of weather, and had her electrical feeling ſtrongeſt in a clear day, or during the paſſage of thunder clouds, when the air is known to be replete with that fluid. Her caſe was decided to be a nervous one.

Two gentlemen of Geneva had a ſhort experience of the ſame complaint, though in a much ſuperior degree. Profeſſor Sauſſure and young Mr. Jalabert, when travelling

travelling over one of the high Alps, were caught amongſt thunder clouds: and to their utter aſtoniſhment, found their bodies ſo full of electrical fire, that ſpontaneous flaſhes darted from their fingers with a crackling noiſe, and the ſame kind of ſenſation as when ſtrongly electrified by art.

It ſeems pretty evident, that theſe feelings were owing to the bodies being poſſeſſed of too great a ſhare of electric fire. This is an uncommon caſe; but it is not at all improbable, that many of our invalids, particularly the hypochondriac, owe their diſagreeable feelings to the oppoſite cauſe, or the bodies being poſſeſſed of too ſmall a quantity of this fire; for we find that a diminution of it in the air ſeldom fails to increaſe their uneaſy ſenſations, and vice verſa.

Perhaps it might be of ſervice to theſe people to wear ſome electric ſubſtance next their ſkin, to defend the nerves and fibres from the damp, or new electric air. I would propoſe a waiſtcoat of the fineſt flannel, which ſhould be kept perfectly clean and dry; for the effluvia of the body in caſe of any violent perſpiration, will ſoon deſtroy its electric quality; this ſhould be covered by another of the ſame ſize of ſilk. The animal heat, and the friction that exerciſe muſt occaſion betwixt theſe two ſubſtances, produce a powerful electricity; and would form a kind of electric atmoſphere round the body, that might poſſibly be one of the beſt preſervatives, againſt the effect of damps.

As for our Swiſs lady I have little doubt that her complaints were owing in great part to her dreſs: and that a very ſmall alteration almoſt in any part of it, would effectually have cured her.

A lady who has her head ſurrounded with wires, and her hair ſtuck full of metal pins, and who at the ſame time ſtands upon dry ſilk, is to all intents and purpoſes an electrical conductor, inſolated, and prepared for collecting the fire from the atmoſphere; and it is not at all ſurpriſing that during thunder ſtorms, or when the air is extremely replete with electrical matter, ſhe ſhould emit ſparks, and exhibit other appearances of electricity. I imagine a very trifling change of dreſs, which from the conſtant verſatility of their modes, may ſome day take place, would render this lady's

diſeaſe

diſeaſe altogether epidemical among the ſex. Only let the ſoles of their ſhoes be made of an electric ſubſtance, and let the wires of their caps and pins of their hair, be ſomewhat lengthened and pointed outwards; and I think there is little doubt, that they will often find themſelves in an electrified ſtate: but indeed if they only wear ſilk, or even worſted ſtockings, it may ſometimes prove ſufficient; for electrometers have been often inſolated as perfectly by placing them on a piece of dry ſilk or flannel, as on glaſs.

How little do our ladies imagine, when they ſurround their heads with wire, the moſt powerful of all conductors; and at the ſame time, wear ſtockings, ſhoes, and gowns of ſilk, one of the moſt powerful repellants, that they prepare their bodies in the ſame manner, and according to the ſame principles as electricians prepare their conductors for attracting the fire of lightning! If they cannot be brought to relinquiſh their wire caps, and their pins, might they not fall upon ſome ſuch preſervatives as thoſe which of late years have been applied to objects of leſs conſideration or conſequence?

11. Next in ſubtlety to this ethereal fluid the ether of plants appears to be. It ſeems to be deſtitute of all groſs air. For exhauſt this ever ſo accurately, it remains unmoved, and does not emit any air-bubbles, which immediately ariſe in other liquors. A little of it poured on the hand, gives a ſenſe of cold, equal to that cauſed by the contact of ſnow. Blow upon it once or twice, and your hand is dry. It cauſes a hiſſing when poured upon warm water, as if a piece of hot iron were thrown into it. Put a lump of ſugar which has imbibed a little of it, into a veſſel full of hot water, the ſugar ſinks; but the ether ruſhing forth, excites a ſtrong ebullition. If a ſpoonful of it be poured into a copper-pot full of boiling water; hold a candle near, and inſtantly there iſſues a great flaſh of lightning. Hence it appears, that this ether, is both a very fluid water, and a moſt ſubtle fire; ſo that if kindled in a thouſand times the quantity of cold water, it burns inextinguiſhably.

It does not manifeſt the leaſt oilineſs to the touch; yet

yet is it the true, natural diſſolvent of all fat oils and gums whatever.

It has a wonderful harmony with gold, even greater than that which is between gold and aqua regia. Diſſolve a piece of gold in aqua regia: on the ſolution cold, pour half an once of ether. Shake the glaſs, and all the gold will paſs into this, and the aqua regia robbed of all its gold, will depoſit a white powder, which ſoon turning green, is the copper wherewith the gold was adulterated. Ether then is the moſt noble and efficacious inſtrument in chymiſtry and pharmacy, inaſmuch as eſſences and eſſential oils are extracted by it immediately, without the mediation of fire, from woods, barks, roots, herbs, flowers, ſeeds, and the various parts of animals.

For inſtance, take mint, ſage, cinnamon, or all together, cut and bottle them; pour on them a ſpoonful or two of ether, and after it has ſtood an hour in a cool place, fill up the bottle with cold water, and preſently you will ſee the eſſential oil ſwimming upon the water. In like manner, though not ſo immediately, it extracts the pureſt gold from any of the baſer minerals. And the gold thus extracted, is better and ſooner purified by this one operation, than by fuſion with antimony. It is the lighteſt of all liquors. Seven ounces of this fill a phial, which contains twenty even of oil of vitriol. And it is the pureſt flame, leaving neither ſoot nor aſhes after its deflagration.

12. Wind is a current of air. Wherever the air is rarefied or condenſed beyond its natural degree, a wind muſt neceſſarily enſue, till the equilibrium be reſtored: the condenſed air immediately expanding itſelf toward that which was rarefied. The cauſe of this condenſation or rarefaction, are heat, cold, and a thouſand things beſide.

The heat in the Weſt-India iſlands would be intolerable, if the winds riſing as the ſun gathers ſtrength, did not blow from the ſea, ſo as to temper the heat even of the noon-day ſun. On the other hand, as the night advances, a breeze ariſes from the land, and blows as from its centre towards the ſea, to all points of the compaſs at once.

At Aleppo the coldeſt winds in the winter are thoſe which blow from N. W. to E. the nearer the Eaſt the colder. But from May 1, to the end of September, the winds blowing from the ſame points, bring with them a heat which one would imagine came out of an oven, and which, when it blows hard will affect metals within the houſes, as if they had been expoſed to the rays of the ſun. Yet it is remarkable, that water kept in jars is much cooler at this time, than when a cool weſterly wind blows.

But what degree of heat can a human body bear? A gentleman, deſirous to aſcertain this, heated ſeveral rooms by means of flues, from 100 degrees of Fahrenheit's Thermometer to 210. He found he could bear the heat of 210 without ſuffering much, and could breathe freely, when his pulſe beat 165 beats in a minute. Even then placing the ball of the thermometer under his tongue, the glaſs ſunk to 100, and the fleſh of his body felt as cold as a corpſe. Yet his watch chain was ſo hot, he could ſcarce touch it.

Hence he inferred that a human body has, to a certain degree a power of deſtroying heat, as well as a power of generating heat, as circumſtances may require. This reſult from the principle of life itſelf, and accordingly is not found in any inanimate body.

A wind of a very peculiar kind, paſſed over the city of Rome, on the night of the 11th of June, 1749. There firſt appeared a very black, long and lofty cloud, which emitted flames on all ſides. It moved along with a ſurpriſing ſwiftneſs, within three or four feet of the ground. It firſt gathered in the neighbouring ſea, came from Oſtia to Rome, entered the city between the gates of St. Paul and St. Sebaſtian, and croſſing in a ſtrait line went out at the north angle of a large ſquare, between the Porta Pia and that of St. Lawrence. It ſtripped off the roofs of houſes, blew down the chimnies, broke doors and windows, forced up the floors, and unpaved the rooms. It tore up the vines, and overthrew the trees in its way, and where its action was moſt violent, the very rafters of the houſes were broke, yea, and hurled againſt houſes at a conſiderable diſtance. The loftieſt buildings felt its fury the moſt: thoſe of one

ſtory

ſtory were little damaged. It was traced to ſome diſtance without the city, then it died away.

The motions of all theſe hurricanes is circular, and they carry up into the air, tiles, ſtones, and whatever comes in their way, and throw them violently to a conſiderable diſtance. To this may be owing ſome of thoſe ſurpriſing ſhowers which are recorded in hiſtory. A whirlwind, for inſtance, paſſes over a place where wool is ſpread to dry. It takes it up, and ſcatters it in ſmall locks, at a conſiderable diſtance. Here is the appearance of a ſhower of wool. If it ſweeps along a mineral rivulet, of which there are many among the mountains of Italy, it carries innumerable metallic particles away, and ſprinkles them on ſome diſtant town or fields. Here is what they call a ſhower of iron.

Hurricanes are foreſeen at the Antibes by a calm, and then a ſhifting of breezes from all quarters; the ſun-ſets blood red, ſmall clouds fly to and fro with great rapidity. Sea-birds quit the air and ſeek the ſhore. Soon after a North breeze ſprings up, which comes to the North-eaſt. Afterwards it is South and South-eaſt, and the air is darkened by a black cloud.

In the laſt hurricane, the wind ſtood at North-eaſt, and blew with ſuch violence, that the largeſt trees were torn up by the roots, their trunks broken to pieces, and not a leaf left on thoſe other trees, which yielded to the fury of the winds. The houſes were thrown down, and the tops of the ſugar-mills, which could not well be thrown down, were cruſhed to pieces. At the end of a hurricane we ſee lightning, and hear the noiſe of thunder. Then the wind ſoftens gradually, till all becomes quiet.

When there was a violent hurricane at Guadeloupe, there appeared upon the iſland, a thick black cloud, which ſeemed on fire, and gravitating toward the earth. It occupied a ſpace of five or ſix leagues in front. Above it the air was almoſt clear, there appearing only a kind of miſt. The whole force of a hurricane is lodged in the very body of a cloud, containing wind, rain, lightning, and thunder: where the air is compreſſed, and rolling upon itſelf, cauſes the ſtorms, which nothing can reſiſt. Nor does the hurricane end,

till the cloud burſts, and the thunder and lightning come on.

One ſpecies of hurricanes is that which is termed a water-ſpout. Theſe are ſeen to deſcend from a cloud as a pillar, having two motions, one round their own axis, the other progreſſive in a ſtrait direction. Such a ſpout is a gyration of clouds, by contrary winds meeting in the centre, and there (where the condenſation and gravitation are greateſt) ſinking down into a great tube, like a ſcrew. In its working and whirling, it ſucks and raiſes the water, in the ſame manner as the ſpiral ſcrew does. One of theſe ſometimes appears on the land. On June 21, ſome years ſince, the clouds near Hatfield in Yorkſhire were obſerved to be much agitated and driven together. They ſoon became very black, and were hurried round: hence proceeded a whirling noiſe like that of a mill. Soon after there iſſued a long tube from the centre of the congregated clouds, having a ſcrew-like motion, by which means the water wherever it came was raiſed up. In Auguſt following, the wind blowing at the ſame time out of ſeveral quarters, created a great whirling among the clouds, the centre of which every now and then ſunk down, like a long, black pipe, wherein was diſtinctly ſeen a motion like that of a ſcrew, continually drawing and ſcrewing up, as it were, whatever it touched. Groves and trees bent under it circularly, like wands. Some of the branches it tore off. It is commonly ſuppoſed, that the water at ſea riſes in a column, before the tube touches it. But this is a miſtake. The tube often touches the ſurface of the ſea, before the water riſes at all.

But water-ſpouts happen ſeveral ways. Sometimes the water is ſeen to boil, and raiſe itſelf for a conſiderable ſpace about a foot from the ſea, before the tube touches it. Above this there appears as it were a thick and black ſmoke, in the midſt of which is a ſort of pipe, reſembling a tunnel, reaching up to the clouds. At other times theſe tunnels come from the clouds, and ſuck up the water with great violence. Sometimes theſe diſcharge themſelves into the ſea, to the unavoidable deſtruction of ſuch ſhips as are in their way: ſometimes

times on the ſhore, beating down all they meet with, and raiſing the ſand and ſtones to a prodigious height.

A very diſtinct account of this kind was given ſome time ſince by an eye witneſs.

" We were on the coaſt of Barbary, when three water-ſpouts came down: one of them bigger than three maſts, the other two ſcarce half as big: all of them were black, as the cloud from which they fell; all ſmooth, and ſmaller at the lower end. Sometimes one became ſmaller, and then larger again; ſometimes it diſappeared, and quickly fell down again.

" There was always a great boiling and flying up of the water, like the appearance of a ſmoking chimney in a calm day. Sometimes it ſtood as a pillar ſome yards above the ſea, and then ſpread itſelf and ſcattered like ſmoke. One ſpout came down to the very middle of this pillar, and joined with it. Afterwards it pointed to the pillar at ſome diſtance, firſt in a perpendicular, and then in an oblique line.

" It was hard to ſay, whether this ſpout fell firſt from the cloud, or the pillar roſe firſt from the ſea, both appearing oppoſite to each other, as in the twinkling of an eye. But in another place the water roſe up to a great height, without any ſpout pointing to it. Only here, the water did not riſe like a pillar, but flew ſcatteringly, and advanced as a moving buſh upon the ſurface of the ſea. This proves that the riſing of the water may begin, before the ſpout from the cloud appears.

" All theſe ſpouts, but eſpecially the great one toward the end, began to appear like a hollow canal, along the middle of which one might diſtinctly perceive the ſea water fly up very ſwiftly: ſoon after the ſpout broke in the middle, and diſappeared by little and little: the boiling up, yea, the pillar of ſea water continuing a conſiderable time after."

There is ſomething very uncommon in the Fetter, a lake which parts eaſt and weſt Gothland. It is about eighty miles long and eighteen broad. Its water is very clear, and in ſome places ſo deep, as not to be ſound-

ed

ed by a line of 300 fathoms. It is often diſturbed by ſtorms, which ſometimes begin ſo ſuddenly, that the ſurface of the water is agitated, before the leaſt breath of wind is perceived. And it is not uncommon for boats in one part of the lake to be toſſed by a violent ſtorm, while others at a ſmall diſtance, are in a perfect calm. Immediately before a ſtorm, while the ſky is clear, a noiſe is perceived in the lake like thunder. Of this the inhabitants of Viſingore, an iſland in the middle of the lake, are more ſenſible than any others. For from that part of the iſland, whence the wind will blow, they hear a noiſe like the firing of cannon. Whenever this is heard in the eaſt, they expect hail and rain to follow. Undoubtedly all theſe ſtorms are owing to ſubterraneous winds. To theſe likewiſe we may attribute the ſudden cracking of the ice upon the lake in the ſpring. This is one minute ſtrong enough to bear horſes and ſledges, and the next broken in pieces. A ſtrange noiſe underneath, which precedes the breach, warns travellers to make the beſt of their way. But thoſe who happen to be at a great diſtance from land, are ſwallowed up, unleſs they can float upon ſhoals of ice, till they meet with relief. The violent under-currents obſerved in this lake, are alſo very ſurpriſing. Theſe directly oppoſing the winds, give the fiſhermen a great deal of trouble. From theſe, as well as from unfathomable depths, it is ſuppoſed to have a communication under ground with another lake, called Venner, about forty miles to the weſtward.

13. It remains only to add a few reflections, on ſome of the preceding heads.

How uſeful is the atmoſphere to the life, the health, the comfort, and the buſineſs of the whole globe? It is the air, † by which all animals live: not only the inhabitants

† As the air is of abſolute neceſſity to animal life, ſo it is neceſſary it ſhould be of a due conſiſtence, not foul, for that ſuffocates; not too thin, for that ſuffices not.

In the diving-bell, after ſome time of ſtay under water, they are forced to come up and take in freſh air. But Cornelius Drebell contrived not only a veſſel to be rowed under water, but alſo a liquor to be carried therein, that would ſupply the want

habitants of the earth, but of the waters too. Without it moſt animals live ſcarce half a minute, and none of them many days.

And not only animals, but even trees and plants owe their life and vegetation to this uſeful element: as is manifeſt from their glory and verdure in a free air, and their paleneſs and ſicklineſs, when excluded from it.

Thus neceſſary is the air to the life of animals, and it is no leſs ſo, to the conveyance of many of them. All the winged tribes owe their flight and buoyancy to it. And even the inhabitants of the waters, cannot eaſily aſcend or deſcend in their own element without it.

It would be endleſs to ſpecify the uſes of the air in the operations of nature. To touch only on one or two inſtances. How admirable is that property of it, the conſerving animated bodies, whether animal or vegetable, while it diſſolves all other bodies; by which means many things which would prove nuiſances to the world, are put out of the way, and reduced to their firſt principles. Even cryſtal glaſſes, eſpecially if not uſed, it will in time reduce to powder. And thus divers minerals, ſtones, foſſil-ſhells, trees, which have lain under-ground for many ages, and ſo ſecure from cor-

want of fresh air. The vessel was made for King James the first. It carried twelve rowers beside the passengers. It was tried in the Thames. A person who was therein told it one who related it to Mr. Boyle. As to the liquor, Mr. Boyle discovered by a physician, who married Drebell's daughter, that from time to time, when the air in the submarine boat was so clogged by the breath of the company, as to be unfit for respiration, by unstopping a vessel full of this, he speedily restored it, so that they breathed again without difficulty.

And as too gross, so too thin an air, is unfit for respiration. Hence the difficulty of breathing, (as all travellers relate) upon the top of high mountains. But the cause of this difficulty is not the thinness only, but the two great lightness thereof, which renders it unable to be a counter-balance to the heart, and all the muscles ministering to the respiration.

ruption,

ruption, when in the open air, have quickly mouldered away.

Another admirable uſe of the atmoſphere is, its miniſtring to the enlightening the earth, by reflecting to us the light of the ſun, § and refracting his beams to our eye, before he ſurmounts our horizon, by which means the day is protracted throughout the whole globe, and the long and diſmal nights are ſhortened in the frigid zones. Yea, the ſun riſes in appearance, when he is indeed many degrees below the horizon.

Let us a little more attentively conſider the light which whitens the ſky before the ſun riſes. There is ſomething ſurpriſing in this. We ſee the light only by the rays which flow to our eyes. Now the ſun being as yet beneath the earth, cannot project any of his rays directly to us. And the rays which dart on the extremities of the land that terminates our ſight proceed farther into the heavens, unleſs they meet with any body, which reflects them back to us. Is there any particular body in nature deſigned to do us this ſervice? There is, namely the atmoſphere, which is framed over our heads in ſuch a manner, that notwithſtanding its extenſive maſs, it ſuffers us to ſee the ſtars, at an immenſe diſtance from us; and notwithſtanding its tranſparency, bends and gathers for us numberleſs rays, of which we ſhould otherwiſe be quite deprived.

Any ray that falls perpendicularly on the atmoſphere, enters it without any obſtacle, and deſcends through it to the earth in the ſame right line. But thoſe which fall obliquely upon it, are admitted into, or repelled from it, according to the ſituation of the luminous body, If this be more than eighteen degrees below the horizon, all it rays are ſcattered abroad. If

§ To this is owing that whiteness which is in the air in the day-time, caused by the rays of light, striking on the particles of the atmosphere, as well as upon the clouds above, and the other objects beneath on the earth. To the same cause we owe the twilight, namely to the sun-beams touching the uppermost parts of the atmosphere, which they do, when the sun is eighteen degrees below the horizon.

leſs,

leſs, the rays enter the atmoſphere, and are refracted to our ſight. This is the true cauſe of the twilight, and indeed of the continuance and principal beauty of the day, even when the ſun is in its higheſt elevation. The earth which receives his rays reflects them into the atmoſphere, which once more returns the greater part of them. Thus it preſerves to us that ſplendor which is the beauty of nature, and that heat which is the ſoul of it. For it collects numberleſs rays, the greater or ſmaller union whereof, is the meaſure of heat and cold. Thus it becomes to us a mantle of the fineſt texture, redoubling the heat, yet not preſſing us by its weight.

The atmoſphere at the ſame time cauſes and maintains round us, that light which lays our whole habitation before our eyes. In order to clear this, ſuppoſe the atmoſphere were deſtroyed, 1. The riſing of the ſun would not be preceded by any twilight, but the moſt intenſe darkneſs would ſurround us, till the moment of his riſing. 2. In that inſtant he would break out in his full brightneſs, and ſo continue till his ſetting: and that moment it would be pitch dark. 3. In the day his light would reſemble a clear fire, which we ſee by night in the midſt of a ſpacious field. We ſhould ſee what was near us, but nothing elſe: the diſtant lands would not be perceived, and the night would ſtill continue, notwithſtanding the ſun. For inſtead of the white tint of day, which diſplays all nature by brightening the azure of the heavens, and colouring all the horizon, we ſhould ſee nothing but an abyſs of darkneſs, there being nothing to reflect the ſolar rays. The ſtars indeed would be ſeen at noon-day: but then thoſe luminous bodies, which now appear to be placed in a delightful azure, would ſeem faſtened on a diſmal, mourning carpet.

"But how does that fine azure depend on the atmoſphere?" This will plainly appear, if it be conſidered, what a quantity of rarefied water is ſuſpended from the top of the atmoſphere to the bottom. And there is never a greater quantity ſuſpended there, than in the fine days, when no clouds are to be ſeen. It is theſe rarefied waters, that intercept, and reflect to us,

the rays reflected from the earth: And this prodigious maſs of waters, being a ſimple and uniform body, the colour of it is ſimple, and always the ſame.

"But are theſe azure ſkies, which we counfound with the ſtarry heaven, nothing more than a little air and water? And what we took for the heaven, only a cover, wrapt cloſe round the earth?" So it is. And this is a new wonder, and a new proof of our Creator's wiſdom! A few ſmall bubbles of air and water are indeed of themſelves things very inſignificant: but that hand which has with ſo much art and caution placed them over our heads, has done it merely, that his ſun and ſtars might not be rendered uſeleſs to us. He embelliſhes whatever he pleaſes; and theſe drops of water and air become in his hands an inexhauſtible ſource of glory. He draws from them thoſe twilights, which ſo uſefully prepare our eyes for the receiving a ſtronger light. He fetches out of them the brightneſs of the dawn. From them he produces the ſplendor of the day. He makes them contribute to the increaſe and preſervation of that heat which nouriſhes every thing breathing. Of them he makes a brilliant arch, which inchants the ſight of man, and becomes the ceiling of his habitation.

I ſhall only add the excellent uſe of the atmoſphere, in reſpect of two of its meteors, the winds, and the clouds and rain.

The winds ‖ are of ſuch abſolute neceſſity to the wholeſomeneſs of the atmoſphere, that all the world would be poiſoned without theſe agitations. We find

‖ The most universal and constant alterations of the balance of the atmosphere are from heat and cold. This is manifest in the general trade-winds, blowing all the year between the tropics from east to west: the cause whereof is undoubtedly by the sun's daily progress round that part of the globe, by his heat rarefying one part of the air, whilst the cooler and heavier air behind passes after.

In thunder-storms there are often two currents of air, the under-current contrary to the upper. Hence the wind near the earth blows one way, and the clouds more above, the other way.

how

how putrid and unfit for reſpiration, a confined, ſtagnating air is. And if the whole maſs of air and vapours were always at reſt, inſtead of refreſhing, it would, ſuffocate all the world. But the motion it receives from the gales and ſtorms, keeps it pure, and healthy ſtill.

Without theſe gales to fan us alſo, in the heat of ſummer, even in our temperate climate, men would hardly be able to get through their daily labour, without endangering their health.† Theſe are perpetual in the torrid zone, and make what the ancients imagined to be not habitable to any but wild beaſts, a healthful and pleaſant habitation.

Of what uſe likewiſe are the winds, to tranſport men to the diſtant regions of the world? Particularly, the general and coaſting trade-winds, the ſea and the land breezes: the one ſerving to carry the mariners in long voyages from eaſt to weſt; the other, to waft him to particular places: the one ſerving to carry him into his harbour, the other to bring him out. Sea-breezes commonly riſe in the morning, about nine o'clock. They firſt approach the ſhore gently, as if they were afraid to come near it. The breeze comes in a fine, ſmall, black curl upon the water, whereas all the ſea between it and the ſhore, is as ſmooth and even as glaſs. In half an hour after it reaches the ſhore, it fans pretty briſkly, and ſo increaſes gradually till twelve o'clock: then it is commonly the ſtrongeſt. It laſts ſo till two or three. At three it begins to die away, till about five it is lulled aſleep. As the ſea-breezes blow in the day, and reſt in the night; the land-breezes blow in the night, and reſt in the day. They ſpring up between ſix and twelve at night, and laſt till ſix, eight, or nine in the morning.

The clouds and rain are no leſs uſeful meteors than the winds, as is manifeſt in the refreſhing ſhade which

† July 8, 1707, called for ſome time after, the hot Tueſday, was ſo exceſſively hot and ſuffocating, by reaſon of there being no wind at all, that divers perſons died in their harveſt-work. A healthy, luſty, young man, near Upminſter in particular, was killed on the ſpot by the heat, and ſeveral travellers on the road dropt down and died.

the clouds afford, and the fertile dews and ſhowers, which they pour down on the trees and plants, which would languiſh and die with perpetual drought, but are hereby made verdant and flouriſhing: ſo that as the Pſalmiſt ſaith, "the little hills rejoice on every ſide, and the vallies ſhout for joy, and ſing."

A farther improvement of theſe remarks I ſubjoin in the words of Mr. Hervey.

"If we turn our thoughts to the atmoſphere, we find a moſt curious and exquiſite apparatus of air. This is a ſource of innumerable advantages; all which are fetched from the very jaws of ruin. To explain this. The preſſure of the air on a perſon of a moderate ſize is equal to the weight of twenty thouſand pounds. Tremendous conſideration! Should a houſe fall upon us with half that force, it would break every bone of our bodies. Yet ſo admirably has the Divine Wiſdom contrived the air, and ſo nicely counterpoiſed its dreadful power, that we ſuffer no manner of inconvenience; we even enjoy the load. Inſtead of being as a mountain on our loins, it is as wings to our feet, or ſinews to our limbs. Is not this common ordination of Providence, ſomewhat like the miracle of the burning buſh? Well may we ſay unto God, O how terrible, yet how beneficent, art thou in thy works!

"The air, though too weak to ſupport our flight is a thoroughfare for innumerable wings. Here the whole common-wealth of birds expatiate, beyond the reach of their adverſaries. Were they to run upon the earth, they would be in ten thouſand dangers, without ſtrength to reſiſt, or ſpeed to eſcape them: whereas by mounting the ſkies, they are ſecure from peril, they ſcorn the horſe and his rider. Some of them perching on the boughs, or ſoaring aloft, entertain us with their notes. Many of them yield us wholeſome and agreeable food, and yet give us no trouble, put us to no expense, but till the time we want them, are wholly out of the way.

"The air is charged alſo with ſeveral offices, abſolutely

lutely needful for mankind. In our lungs it ventilates the blood, qualifies its warmth, promotes the animal ſecretions. We might live even months, without the light of the ſun, yea, or the glimmering of a ſtar. Whereas, if we are deprived but a few minutes of this, we ſicken, we faint, we die. The ſame univerſal nurſe has a conſiderable ſhare in cheriſhing the ſeveral tribes of plants. It transfuſes vegetable vigour into the trunk of an oak, and a blooming gaiety into the leaves of a roſe.

"The air likewiſe conveys to our noſtrils the extremely ſubtle effluvia which exhale from odoriferous bodies: particles ſo ſmall, that they elude the moſt careful hand. But this receives and tranſmits the inviſible vagrants, without loſing even a ſingle atom; entertaining us with the delightful ſenſations that ariſe from the fragance of flowers, and admoniſhing us to withdraw from an unwholeſome ſituation, to beware of pernicious food.

"The air by its undulating motion conducts to our ear all the diverſities of ſound. While danger is at a conſiderable diſtance, this advertiſes us of its approach; and with a clamorous, but kind importunity, urges us to provide for our ſafety.

"The air wafts to our ſenſe all the modulations of muſic, and the more agreeable entertainments of converſation. It diſtributes every muſical variation with the utmoſt exactneſs and delivers the meſſage of the ſpeaker with the moſt punctual fidelity: whereas without this internuntio, all would be ſullen and unmeaning ſilence. We ſhould neither be charmed by the harmonious, nor improved by the articulate accents.

"How gentle are the breezes of the air when unconfined! but when collected, they act with ſuch immenſe force, as is ſufficient to whirl round the hugeſt wheels, though clogged with the moſt incumbering loads. They make the ponderous millſtones move as ſwiftly as the dancer's heel; and the maſſy beams play as nimbly as the muſician's fingers.

"In

In the higher regions there is an endleſs ſucceſſion of clouds, fed by evaporations from the ocean. The clouds are themſelves a kind of ocean, ſuſpended in the air. They travel in detached parties, over all the terreſtrial globe. They fructify by proper communications of moiſture, the ſpacious paſtures of the wealthy, and gladden with no leſs liberal ſhowers the cottager's little ſpot. Nay, they "ſatisfy the deſolate and waſte ground, and cauſe the bud of the tender herb to ſpring forth:" that the natives of the lonely deſert, the herds which know no maſter's ſtall, may nevertheleſs experience the care of an all-ſupporting parent.

"How wonderful! That pendant lakes ſhould be diffuſed, fluid mountains heaped over our heads, and both ſuſtained in the thinneſt part of the atmoſphere. How ſurpriſing is the expedient which without veſſels of ſtone or braſs, keeps ſuch loads of water in a buoyant ſtate? Job conſidered this with holy admiration. "Doſt thou know the balancing of the clouds?" How ſuch ponderous bodies are made to hang in even poiſe, and hover like the lighteſt down? "He bindeth up the waters in his thick cloud:" and the cloud, though nothing is more looſe and fluid, becauſe by his order tenacious, as caſks of iron, is not rent under all the weight.

"When the ſluices are opened and the waters deſcend, one would think they ſhould pour down in torrents. Whereas inſtead of this, which would be infinitely pernicious, they coaleſce into globules, and are diſpenſed in gentle ſhowers. They ſpread themſelves as if ſtrained through the orifices of the fineſt watering-pots, and form thoſe ſmall drops of rain which the clouds diſtil upon man abundantly. Thus inſtead of drowning the earth, and ſweeping away its fruits, they cheriſh univerſal nature, and (like their great maſter) diſtribute their ſtores, to men, animals, and vegetables, as they are able to bear them.

"But beſide waters, here are cantoned various parties of winds, mild or fierce, gentle or boiſterous, furniſhed with breezy wings, to fan the glowing firmament,

ment, or elſe fitted to act as an uiverſal beſom, and by ſweeping the chambers of the atmoſphere to cleanſe the fine aëreal fluid. Without this wholeſome agency of the winds, the air would ſtagnate and become putrid: ſo that all the great cities in the world, inſtead of being ſeats of elegance, would degenerate into ſinks of corruption.

" At ſea, the winds ſwell the mariner's ſails, and ſpeed his courſe along the watery way. By land they perform the office of an immenſe ſeeds-man, ſcattering abroad the ſeeds of numberleſs plants, which, though the ſupport of many animals, are too ſmall for the management, or too mean for the attention of man.

" Here are lightnings ſtationed, in act to ſpring whenever their piercing flaſh is neceſſary, either to deſtroy the ſulphureous vapours, or diſlodge any other noxious matter, which might prejudice the delicate temperature of the ether, and obſcure its more than cryſtalline tranſparency.

" Above all is ſituate a radiant and majeſtic orb, which enlightens and cheers the inhabitants of the earth: while the air, by a ſingular addreſs, amplifies its uſefulneſs. Its reflecting power augments that heat, which is the life of nature: its refracting power prolongs that ſplendor, which is the beauty of the creation.

" I ſay, augments the heat. For the air is a cover which, without oppreſſing us with any perceivable weight, confines, reflects, and thereby increaſes the vivifying heat of the ſun. The air increaſes this, much in the ſame manner as our clothes give additional heat to our body: whereas when it is leſs in quantity, when it is attenuated, the ſolar heat is very ſenſibly diminiſhed. Travellers on the lofty mountains of America, ſometimes experience this to their coſt. Though the clime at the foot of thoſe vaſt mountains, is extremely hot and ſultry, yet at the top the cold is ſo exceſſive, as often to freeze both the horſe and rider to death. We have therefore great reaſon to praiſe God,

God, for placing us in the commodious concavity, the cheriſhing wings of an atmoſphere.

" The emanations of light, though formed of inactive matter, yet (aſtoniſhing power of divine wiſdom!) are refined almoſt to the ſubtlety of ſpirit, and are ſcarce inferior even to thought in ſpeed. By which means they ſpread with almoſt inſtantaneous ſwiftneſs, through a whole hemiſphere: and though they fill whatever they pervade, yet they ſtraiten no place, embarraſs no one, incumber nothing.

" Every where indeed, and in every element we may diſcern the footſteps of the Creator's wiſdom. The ſpacious canopy over our heads is painted with blue; and the ample carpet under our feet is tinged with green. Theſe colours, by their ſoft and cheering qualities, yield a perpetual refreſhment to the eye. Whereas had the face of nature glittered with white, or glowed with ſcarlet, ſuch dazzling hues, inſtead of cheering, would have fatigued the ſight. Beſides, as the ſeveral brighter colours are interſperſed, and form the pictures in this magnificent piece, the green and the blue make an admirable ground, which ſhews them all to the utmoſt advantage.

" Had the air been much groſſer, it would have dimmed the rays of the ſun and darkened the day. Our lungs would have been clogged in their vital function, and men drowned or ſuffocated therein. Were it much more ſubtle, birds would not be able to wing their way through the firmament: neither could the clouds be ſuſtained, in ſo thin an atmoſphere. It would elude likewiſe the organs of reſpiration: we ſhould gaſp for breath with as much difficulty, and as little ſucceſs as fiſhes do, when out of their native element.

" The ground alſo is wrought into the moſt proper temperature. Was it of a firmer conſiſtence it would be impenetrable to the plough and unmanageable by the ſpade. Was it of a more looſe compoſition, it would be incapable of ſupporting its own furniture. The light mould would be ſwept away by whirling winds,

winds, or ſoaked into ſloughs by the deſcending rains. Again, becauſe every place ſuits not every plant, but that which nouriſhes one, deſtroys another: the qualities of the earth are ſo abundantly diverſified as to accommodate every ſpecies. We have a variety of intermediate ſoils, from the looſe ſand to the ſtiff clay: from the rough projection of the craggy rock, to the ſoft bed of the ſmooth parterre.

" The ſea carries equal evidences of a moſt wiſe and gracious ordination. Was it larger, we ſhould have wanted land for paſturage and huſbandry. We ſhould not have had room for mines and foreſts, our ſubterranean warehouſes and aëreal timber-yards. Was it ſmaller, it could not recruit the ſky with a proper quantity of exhalations: nor ſupply the earth with the neceſſary quota of fructifying ſhowers.

" May we not diſcover as exquiſite ſtrokes of wiſdom in each individual object? All that ſhines in the heavens, and all that ſmiles on the earth, ſpeak their infinitely wiſe Creator. Need we launch into the praiſe of the vallies clothed with graſs, or of the fields repleniſhed with corn? Even the ragged rocks, which frown over the flood, the caverned quarries which yawn amidſt the land, together with the ſhapeleſs and enormous mountains, which ſeem to load the ground, and encumber the ſkies; even theſe contribute to increaſe the general pleaſure, and augment the general uſefulneſs. They add new charms to the wide level of our plains, and ſhelter, like a ſcreen the warm lap of our vales.

" Who is not charmed with the delicious fruits of ſummer and autumn? But were all our trees and ſhrubs to produce ſuch fruits, what would become of the birds? How ſmall a part would voracious man reſign to their enjoyment? To provide therefore for each vagrant of the air, as well as for the ſovereign of a nation, there is in all places a large growth of ſhrubs annually covered with coarſe and hardy berries: ſo courſe in their taſte, that they are unworthy of the acceptance of man: ſo hardy in their make, that they endure the utmoſt ſeverity of the weather, and furniſh

the

the feathered tribes with a ſtanding repaſt amidſt all the deſolations of winter.

" The fir, the beech, the elm, are ſtately decorations of our rural ſeats. But if there were no entangling thickets, no prickly thorns, where would the farmer procure fences? How could he ſecure his vegetable wealth, from the flocks and the herds? Thoſe roving plunderers, which ſubmit to no laws, but thoſe of the coercive kind.

" We ſpare no toil, to have uſeful herbs and plants in our gardens, and upon our tables. But there are innumerable herbs, which paſs under the contemptible character of weeds, and yet are full as deſirable to other claſſes of creatures, as theſe are to mankind. Yet who will be at the pains to plant, to water, to cultivate, ſuch deſpicable productions? Man would rather extirpate than propagate, theſe incumbrances of his land. Therefore Providence vouchſafes to be their gardener, and has wrought off their ſeeds with ſuch a lightneſs, that they are tranſported to and fro, by the mere undulations of the air. Or, if too heavy, to be wafted by the breeze, they are faſtened to wings of down: or elſe incloſed in a ſpringy caſe, which forcibly burſting, ſhoots them out on every ſide. By ſome ſuch means, the reproducing principle of every one is diſſeminated, the univerſal granary filled, and the univerſal board furniſhed. The buzzing inſect and the creeping worm, have each his bill of fare. Each enjoys a never-failing treat, equivalent to our greateſt delicacies.

" If graſs was ſcarce as the Guernſey-lilly, and as difficultly raiſed as the Tuberoſe, how certainly, and how ſpeedily, muſt many millions of animals periſh by famine? But as all the cattle owe their chief ſubſiſtence to this, by a ſingular wiſdom in the divine œconomy, it waiteth not like the corn field, and the garden-bed, for the annual labours of man. When once ſown, though ever ſo frequently cropt, it revives with the returning ſeaſon. With a kind of perennial verdure, it covers our meadows, diffuſes itſelf over the plains,

plains, ſprings up in every glade of the foreſt, and ſpreads a ſide-board in the moſt ſequeſtered nook.

" Such is the care of a wiſe and condeſcending Providence, even over theſe loweſt formations of nature!"

PART THE FIFTH.

OF THE

SYSTEM OF THE WORLD;

OF THE

HEAVENLY BODIES;

AND OF THE

Properties and Causes of Natural Bodies.

CHAP. I.

Of the System of the World.

1. *The General Phænomena of the Sun and Moon.*
2. *Of Mercury and Venus.*
3. *Of the other Planets.*
4. *Of the Comets and fixed Stars.*
5. *The Ptolemaic Syſtem.*
6. *The Copernican.*
7. *The Syſtem of Tycho Brache.*
8. *The Hutchinſonian Syſtem.*
9. *Advantages from the Rotation of the Earth.*

1. HAVING conſidered the earth, with the bodies that are therein, let us now look up to thoſe that ſurround it. The world is a congeries of innumerable

merable bodies, many of which are ſuppoſed to equal or exceed the ſize of the earth: yet by reaſon of their diſtance, moſt of them are inviſible to the naked eye.

The neareſt to us is the moon, which moves round the earth in ſomething more than twenty-eight days from weſt to eaſt. The ſun likewiſe ſeems to move from eaſt to weſt, and ſhines ſucceſſively on all parts of the globe. It appears alſo to us to move every year obliquely from weſt to eaſt, coming twenty-three degrees and a half to the north, and then going juſt as far to the ſouth.

2. Some of the ſtars keep always the ſame diſtance, with reſpect to each other and are termed fixed. Others are continually changing their ſituation, whence they are termed planets. Two of theſe, mercury and venus, are frequently between the earth and the ſun: of which the former being generally hid by the rays of the ſun, is ſeldom viſible: but venus, commonly called the evening ſtar, is very conſpicuous. The earth is never between them and the ſun. They are ſometimes between us and him. Sometimes the ſun is interpoſed between us and them.

3. The upper planets are mars, jupiter, and ſaturn. The ſun is ſometimes between theſe and the earth. But none of them is ever interpoſed between the earth and the ſun. Mars has different appearances, like the moon, as it is differently ſituated, with regard to the ſun: whereas jupiter and ſaturn always appear with the ſame aſpect, and have ſmaller planets revolving round them. All theſe revolve round the ſun, in their ſeveral ſtated periods.

4. Beſide theſe, there is another kind of ſtars called comets, vulgarly blazing ſtars. Theſe do not revolve round the ſun in ſo regular orbits as the planets. The fixed ſtars are above theſe: about 2200 are viſible to the naked eye. Theſe have a vivid light, and always appear with the ſame face towards us: they ſeem to have a twofold motion, a ſlow one from eaſt to weſt in a year, and a ſwift one round the earth with all the other

other ſtars in four and twenty hours. But there are ſome of them which never ſet, namely thoſe near the north or ſouth pole.

5. To explain theſe phenomena of the heavenly bodies, various ſyſtems have been invented. The Ptolemaic, ſuppoſes the earth to be fixed in the centre of the univerſe, round which all the heavenly bodies move, each affixed to a ſolid ſphere which moves with it: firſt the moon, then mercury, thirdly venus, next the ſun, fifthly mars, then jupiter, ſeventhly ſaturn. In the eighth place is the firmament or ſphere of fixed ſtars; then the cryſtalline heaven, and laſt of all the primum mobile, which is ſuppoſed to move from eaſt to weſt in twenty-four hours, whirling all the other ſpheres with it. But this ſyſtem being in ſome reſpects obviouſly falſe, in others utterly improbable, and likewiſe inſufficient to account for many phenomena, is now univerſally exploded.

6. In the room of this, the Copernican ſyſtem is now generally received, which ſuppoſes the ſun, to be fixed in the centre, without any other motion, than that round his own axis. Next him is mercury, then venus, thirdly the earth, (round which the moon revolves) above the earth, mars, then jupiter, and ſaturn, with their attendant moons. This ſyſtem is extremely ſimple and natural, and eaſily accounts for moſt phenomena. As to the objection, that it is contrary to the teſtimony of our ſenſes, it is eaſily anſwered. They who are in a ſhip ſeem to ſee the ſhore and the land moving along, although it is really the ſhip that moves. Yet let it move ever ſo ſwiftly, it diſplaces nothing, provided it move ſmoothly. So neither does the motion of the earth diſplace any thing on its ſurface, becauſe it is equable and regular.

Not that Copernicus was the inventor of this ſyſtem. It was in great part known long ago. Pythagoras taught, "that the earth was carried about the ſun among the ſtars, and by turning round its axis, cauſed day and night." Yet by degrees it ſunk into oblivion, till it was revived by Cardinal Cuſa. However, the Ptolemaic ſyſtem ſtill prevailed, till Nicholas Copernicus,

nicus, a canon of Thorn, in Poliſh Pruſſia, born in the year 1473, had reſolution to examine it thoroughly, and learning enough to explain and defend it. Some of the reaſons on which this ſyſtem is founded are, 1. This is moſt ſimple and agreeable to the whole tenure of nature: for by the two motions of the earth all the phenomena of the heavens are reſolved, which on any of the other hypotheſes are utterly inexplicable. 2. It is more rational to ſuppoſe the earth moves round the ſun, than that the huge bodies of the planets and of the ſun itſelf, and the immenſe firmament of ſtars, ſhould all move round the inconſiderable body of earth every four and twenty hours. 3. The earth's moving round the ſun is agreeable to that general harmony and univerſal law, which all other moving bodies of the ſyſtem obſerve, namely, that the ſquares of the periodical times are as the cubes of the diſtances. But if the ſun move round the earth, that law is deſtroyed, and the general order and ſymmetry of nature interrupted; becauſe according to that law the ſun would be ſo far from revolving about the earth in 365 days, that it would require not leſs than 5198 years, to finiſh one revolution. 4. The ſun is the fountain of light and heat, which it darts through the whole ſyſtem, and therefore it ought to be placed, as the heart in the centre, that ſo all the planets may at all times, have them, in an uniform and equal manner. 5. If the ſun be placed in the centre of the ſyſtem, we have then the rational hypotheſis of the planets being all moved about the ſun, by the univerſal law of gravity: and every thing will anſwer to that law; but otherwiſe we are wholly in the dark. 6. But we need not rely upon conjectures. We have demonſtrative proofs, that the ſun poſſeſſes the centre, and that the planets move round it, in the order above mentioned. For example. Mercury and Venus are ever obſerved to have two conjunctions with the ſun, but no oppoſition, which could not happen unleſs the orbits of thoſe planets lay within the orbit of the earth. And in the ſame manner it may be demonſtrated, that the orbits of mars, jupiter, and ſaturn lie without the orbit of the earth.

7. After Copernicus came Tycho Brache, a noble Dane,

Dane, who endeavoured to compound a ſyſtem of the Ptolemaic and Copernican put together; but it was quickly found by all unprejudiced judges to be ſo intricate and peplexed, that it had not many aſſertors even while he lived, and is now well nigh ſunk into oblivion.

8. Mr. Hutchinſon (not the profeſſor of Glaſgow, but a private Engliſh gentleman) ſuppoſes the conſtituent parts of heaven to be, 1. The darkneſs or dark air, which is no other than the fine ether in a ſtate of ſtagnation: 2. The ſpirit, or the air in a ſenſible motion: 3. The light, the fineſt part of the heavens, the pure ether in motion: 4. The luminaries and the fluxes. Underſtand by the luminaries, the bodies of the ſun, moon, and ſtars: by their fluxes the flow of light that comes from each of them. Revelation conſtantly diſtinguiſhes theſe. Therefore it is very improper for us to confound them together. Indeed every one knows, that though the bodies of the ſun, moon, and ſtars, take up but a ſmall part of the heavens, yet the fluxes of light from them diffuſe themſelves throughout all nature.

The ſpringing forth of the ſolar light cauſes the morning; its going off the evening. Its being intercepted by the body of the earth cauſes night; its ſhining cauſes day. It acts in a mechanical way, and is part of the great machine of nature. It is in continual motion to and from the body of the ſun: going out from the centre to the circumference of the heavens, and returning to the centre again. The ſolar light, along with the ſpirit, which continually attends it, is the cauſe of the regular returns of morning and evening, ſummer and winter. The ſpirit and light are properly the agent, and the earth only the patient. Its motion round its axis, and round the ſun, and its inclining northward and ſouthward at different times, are all produced by the action of the light going outward, and the ſpirit returning inward. 5. The denſities, which form the extremity of the whole ſyſtem of nature; the denſe, groſs air, out of which the fine ether is extracted, and into which it returns. The heavens will naturally be groſſer and groſſer, the farther

ther from the ſun, till perhaps at the utmoſt extremity, they are condenſed into an immoveable ſolid.

Theſe are the conſtituent parts of the heavens. And hence we have reaſon to conceive, that all theſe parts, (the ſun, moon and ſtars excepted) are no other than the different ſtates into which the ethereal fluid does or may paſs. For the darkneſs is the fine atoms of the heaven in a ſtate of inactivity. The ſpirit is the groſſer parts of the heavens or maſſes compreſſed together; while the light is the atoms or fineſt part of the ether in ſwift motion. At the centre, the commotion is greateſt, and gradually decreaſes towards the circumference, where the ether is very much condenſed, and this is called the denſity.

He farther ſuppoſes, that the ſun is the centre of the whole univerſe; that the fixed ſtars are all placed in the denſity, not far from each other, and abundantly nearer the earth, than common aſtronomers imagine, and that their uſe is not to perform the office of ſuns to other planets, but to aſſiſt in that cold region, to ſupply in ſome degree, the want of the ſolar fire.

Perhaps it may not be unacceptable to the ſerious reader, to give a more particular account of this ingenious hypotheſis, in the words of a late writer. The ſum of what Mr. Hutchinſon avers, is, That beſide the differently formed particles of which the earth, and the ſeveral ſolid ſubſtances in it, and in the other orbs, are compoſed; God at firſt created all that ſubtle fluid which now is, and from the creation has been in the condition of fire, light or air, and goes under the name of the heavens.

The particles of this fluid (which he calls atoms) when they are ſingle and uncompounded, are inconceivably minute, and ſo ſubtle as to pervade the pores of all ſubſtances whatever, whether ſolid or fluid. When they are puſhed forward in ſtrait lines, by the action of fire, or are reflected or refracted in ſtrait lines, they produce light, and are ſo called. When the interpoſition of opaque bodies hinders their progreſs in ſtrait lines, they paſs, but ceaſe to produce light.

Theſe particles, which when moving in ſtrait lines produce light, and when collected and put into another

ſort

ſort of motion, produce fire, when the force impelling them ceaſes to act with vigour, and when their motion is retarded, cohere in ſmall maſſes or grains, which Mr. Hutchinſon calls ſpirit or air, and is of the ſame kind and texture, with that air, which we daily breathe.

The ſun, fixed at the centre of this ſyſtem, is included in a vaſt collection of this ſubtle matter, in the form of fire, which continually melts down all the air that is brought into it from all parts of the ſyſtem, into atoms, and with an immenſe force ſends it forth, in perpetual ſtreams of light, to the circumference. The whole ſpace comprehended within this, is abſolutely full.

The matter thus melted down at the orb of the ſun, moves outward to the circumference, and being forced by the particles which are concreted into air at the utmoſt extremities, returns toward the ſun, where the fluid, being moſt ſubtle, gives leaſt reſiſtance, and takes up the place that the light left.

And therefore this uninterrupted flux of matter from the ſun in light, in place of being an expence which would neceſſarily deſtroy that orb (an inſupportable objection, Mr. Hutchinſon thinks, to Sir Iſaac Newton's ſcheme,) is the very means of preſerving it, and every thing elſe in this ſyſtem, in its action and vigour, by preſſing back perpetual ſupplies of air, to be melted down into light, which produces a continual circulation. Theſe perpetual tides of matter outwards and inwards, in every point from the centre to the circumference, produce that conſtant gyration in the earth, and the planets round their own centre, and round the ſun.

Beſides the rotation of the orbs, the adverſe motion of the light puſhing toward the circumference, and the air puſhing toward the centre with immenſe force, brings that compreſſure on all the bodies it meets, that binds together ſolids, keeps fluids as they were, cauſes the riſing of water, the production of vegetables and animals, and in ſhort produces all the effects uſually aſcribed to gravitation or attraction; continues motion without the aſſiſtance of the unmechanical principle of projection, and is indeed the real cauſe of almoſt all the effects and phenomena in nature.

As immenſely different as this is, from all the other ſyſtems of aſtronomy, very probable arguments are alledged in confirmation of it. And more than probability, I doubt, we ſhall never attain, with regard to things at ſo great a diſtance from us.

But what a ſtrange diſcovery is that, which has been lately communicated by an eminent profeſſor to the Royal Society? "Having carefully examined, the modern obſervations of the ſun, with thoſe of ſome centuries paſt, though I have gone no farther back than the fifteenth century, yet I have obſerved that the motion of the ſun, (or of the earth) is ſenſibly accelerated ſince that time, ſo that the years are ſhorter now than formerly. The reaſon of this is very natural. For if the earth in its motion ſuffers ſome reſiſtance (which cannot be doubted, ſince the ſpace through which the planets paſs, is full of ſome ſubtle matter, were it no other than light) this reſiſtance will gradually bring the planets nearer and nearer the ſun. And as their orbits thereby become leſs, ſo their periodical times will be diminiſhed. Thus in time the earth would come within the regions of venus, then of mercury, where it would neceſſarily be burnt. Hence it is manifeſt, that the planetary ſyſtem cannot laſt for ever in its preſent ſtate: as alſo that this ſyſtem muſt have had a beginning; otherwiſe there muſt have been a time when the earth was at the diſtance of ſaturn: conſequently no living creature could ſubſiſt there. This then is a clear proof, that the world in its preſent ſtate had a beginning, and muſt have an end.

We may likewiſe find reaſon to think, from the action of jupiter on the earth, that the earth's revolution round its axis, continually becomes more and more rapid. For the force of jupiter ſo accelerates the motion of the earth round the ſun, that the diminution of the years would be ſenſible, if the diurnal motion had not been accelerated nearly in the ſame proportion.

It is another obſervation of aſtronomers, that the ſun does not ſhine as long on one ſide the line as on the other: that he ſtays longer in the ſix northern ſigns, than in the ſix ſouthern: ſo much longer, as to make

no

no leſs a difference, than that of nine days. How is this? Did the earth always obvert her northern hemiſphere to the ſun ſo much longer than the ſouthern? Or has ſhe gradually warped ſo much to one ſide, in a courſe of near 6000 years?

But over and above the ſun's motion round his own axis, in 25 days, 15 hours, he has another motion. There is a certain point, which is the true or common centre of all the planetary motions, not quite a ſemi-diameter of the ſun diſtant from its centre. About this point, the ſun and all the planets move; but in what time is uncertain.

9. Let us conſider more cloſely, the advantages ariſing to us by the rotation of the earth about its own axis. We are ſo made, that once in ſixteen or twenty hours at moſt, we require a time for relaxation. And generally in healthful people this time is pretty equal, between ſix and eight hours. The ſtorehouſes of our ſpirits, will not a permit a longer application than twenty hours, without injury to our conſtitutions. And at leaſt ſix hours are required to fill them again.

It was likewiſe neceſſary that the air ſhould be cool and temperate, during the time of this reſt; for we generally find thoſe that ſleep while the ſun is above the horizon, the worſe for it, the ſun and the heat exhaling the natural perſpirations too violently, and raiſing too quick a motion in the blood. And though we generally perſpire more in the night, yet the perſpiration is more natural and leſs violent, and more according to the neceſſities of our conſtitutions in the night than in the day. Beſides, the darkneſs is leſs ſubject to noiſe and diſturbance than the day. Now all theſe things are wonderfully provided for, by the rotation of the earth about its axis. For thereby we have the viciſſitudes of day and night, the day for ſpending our ſpirits, the night to recruit them; as alſo for nouriſhing the muſcles, bones, channels, and other parts of the body; for the buſineſs of nutrition is moſtly, if not altogether, performed in the time of reſt. Likewiſe, how comfortable and refreſhing are the cool breezes of the night; and the trade-winds to thoſe that live un-

der the equatorial parts? Without which, life would both be exceeding ſhort, and very grievous.

Theſe winds, are the neceſſary effect of the rotation of the earth about its axis, which under the line makes the rays of the ſun direct and equal all the year round; ſo that theſe parts being conſtantly under the ſun's influence, his heat rarefies one part of the air, and the cooler and heaveir part preſſes upon the hotter, and ſo makes a continual wind in his courſe from eaſt to weſt.

Morever, let us reflect upon our vegetables, which are the ſupport of animals; the ſun rarefies and conſequently raiſes the ſizy vegetable juices, at the roots of the tender ſeeds, and thereby forces the folded branches to expand and enlarge. Now, were the ſun conſtanly ſhining upon them, theſe juices would not be at liberty to ſettle, and conſolidate in the fit places of the branches; but would be ſtill riſing higher and higher, till at laſt they burſt the canals; whereas by this viciſſitude of heat and cold, what is raiſed in the day time, has time to ſettle and conſolidate in the night. Its cold turns the thin juices into ſizy ſubſtances, which the ſupervening heat, by exhaling the watry parts, hardens and fixes. On the other hand, had not the earth moved upon its axis, but only turned round the ſun in its annual period, we had not only loſt all theſe advantages, which are ſo neceſſary for both animals and vegetables, but had ſuffered alſo ſuch inconveniences, as neither of theſe could poſſibly bear. For near half the year, we ſhould have been in perpetual darkneſs, the conſequence of which would have been, that baleful damps, by the preceding heat, generated and raiſed, would have fallen, which would have ſtifled all animals. Or had they ſurvived that, ſnow, ice, and froſt, would not only have locked up all fluids, but would have froze the blood and ſpirits in the channels of all the animals we are acquainted with.

Again, in the enlightened half of the year, we ſhould have had huge deluges of water, from the preceding ſnow, which likewiſe would have produced ſuffocating miſts. Next, all our ground would have turned

turned into a ſtiff, ſtinking puddle, being in a manner diſſolved by the ſnow water. Then would ſultry heats and a burning air, have ſcorched, and chopped the earth, and galled the animal tribes, ſo that they would have found reſt, neither in houſes nor dens, till at laſt, the blood and ſpirit of all the animals of our globe, would be quite exhaled, or by the violent agitation thereof, they would turn delirious.

Upon all theſe accounts, the rotation of the earth, about her axis, is one of the moſt ſignal inſtances of Divine Wiſdom.

CHAP. II.

Of the Heavenly Bodies in particular.

1. *Of the Sun.*
2. *Mercury.*
3. *Venus.*
4. *The Earth.*
5. *The Moon.*
6. *Of Mars.*
7. *Jupiter.*
8. *Saturn.*
9. *Comets.*
10. *The fixed Stars.*
11. *Reflections.*
12. *Doubts concerning the modern Aſtronomy.*

1. THE very ſame effects which we obſerve daily in fire, we obſerve alſo in the ſun. It ſhines, it warms, it burns. Viewed with a teleſcope it appears like an ocean of fire or melted metal. Hence many ſuppoſe, that the ſpots appearing thereon and changing continually, are as it were the droſs and

ſcum

ſcum of that metal, which it throws out from time to time. But it is more probable, ſome of thoſe ſpots are clouds, formed out of the ſolar exhalations. And if exhalations riſe out of his body, and are ſuſpended at a certain height from it, then the ſun muſt be encompaſſed with a fluid, analogous to our atmoſphere. Some of theſe ſpots diſſolve and diſappear, in the very middle of the ſun's diſk: that is, the exhalations ſometimes riſe, ſometimes fall back to the ſun.

But there is another kind of ſpots which regularly revolve, once in ſeven and twenty days. Or to ſpeak more properly, the ſun himſelf revolves nearly in that time, round his own axis, together with his atmoſphere.

But over and above this motion on his own axis, "We are not ſure, ſays Mr. Huygens, whether the ſun be a ſolid or liquid globe. I rather think it liquid, which the equal diſtribution of his light to all parts is an argument for. That very ſmall inequality on his ſurface, diſcovered by the teleſcope, which has made ſome men imagine they ſaw huge mountains of fire, is entirely owing to the trembling motion of the vapours our atmoſphere is full of, particularly near the earth. And this is likewiſe the cauſe of the ſtars twinkling.

"The dark ſpots in the ſun I have often ſeen: but thoſe bright ſpots of which many ſpeak, I never was able to diſcover: ſo that I cannot but doubt of their exiſtence. Nor do I apprehend there is any thing in or upon the ſun, brighter than the ſun itſelf. Indeed it is not pretended that theſe bright ſpots are any where, but juſt about the dark ones. And it is no wonder, the parts which are near the dark, ſhould appear ſomewhat brighter than the reſt."

And hence it is, that thoſe ſpots being viewed obliquely, near the edge of the ſun, appear narrow and oblong. He is ſuppoſed to be abundantly larger than the earth. When the moon paſſes between the earth and the ſun, ſo as to intercept his rays, he is ſaid to be eclipſed. This happens only at the time of the new moon, becauſe it is then only ſhe paſſes between the ſun and the earth. Yet not at every new moon, becauſe ſhe gene ally declines either to the north or ſouth.

No

No ſolar eclipſe can be univerſal, the moon being too little to overſhadow the whole earth. Nor does any eclipſe appear the ſame in all places, but is total in one, and partial in another. In moſt ſolar eclipſes, the moon is covered with a faint, dawning light, which is owing to the reflection of the light from the illuminated parts of the earth. In total eclipſes the moon's edge is ſeen ſurrounded by a pale circle of light, which is at leaſt a probable indication of a lunar atmoſphere.

When the earth is interpoſed between the moon and the ſun, then the moon is eclipſed. This is only at the time of the full moon. Even in the midſt of the eclipſe, the moon has a faint light which is reflected by the atmoſphere of the earth. And to the ſhadow of this it is owing, that ſhe grows paler and dimer, before ſhe enters into the ſhadow of the earth.

2. The planet neareſt to the ſun is mercury, which is the ſmalleſt of all, ſuppoſed to be twelve times leſs than the earth. It moves round the ſun in about three months, and is believed to be the moſt denſe of all the heavenly bodies. It ſometimes moves between the earth and the ſun. And from its various appearances we may certainly infer, that it has no light of its own, but ſhines by reflection only.

3. The next to mercury is venus, whoſe appearances likewiſe change in the ſame manner as the moon's. It is ſuppoſed to be ſomething leſs than the earth, and completes its period round the ſun, in nearly ſeven months. From its ſituation we may judge, it is more denſe than the earth, but more rare than mercury.

4. Next to venus is the earth, which moves round its own axis from weſt to eaſt in twenty-four hours, and round the ſun in three hundred and ſixty-five days, five hours and near forty-nine minutes.

The difference of ſeaſons, as well as the different degrees of heat and cold, depend on the different poſitions of the earth with reſpect to the ſun. The natural ſtate of this globe ſeems to be what we call temperate. This is what ſecures ſprings and other bodies from

from being frozen. But the obliquity and perpendicularity with which the rays of the ſun fall on the air, are varying continually, according to which the warmth of the air is continually leſſening or increaſing. Likewiſe the continuance of the ſun's preſence, with the ſlowneſs of his motion, naturally increaſe heat: as his abſence and the ſwiftneſs of his motion, naturally increaſe cold. Yet this rule does not always hold. There are many accidents that prevent it: ſuch as the ſituation of hills, and the declivity of land, towards the north or ſouth. Clouds alſo ſometimes reflect heat, and water-clouds cool the air. South or ſouth-weſt winds, if without rain, increaſe warmth; eaſt or northerly winds occaſion cold. Whenever ſmooth water reflects the ſun's rays, it much increaſes heat. And indeed all ſmooth bodies which reflect light, reflect heat along with it, and that more or leſs, according to the cloſeneſs of the pores, and the extent, convexity or concavity of their ſurface.

All parts of the earth enjoy nearly the ſame quantity of the ſun's preſence in the ſame ſpace of a year. And yet how widely different is the quantity of heat, in ſome from that in others? But it is not, as any one would imagine greateſt under the line. This is prevented by the ſwiftneſs of his motion. For the nearer he approaches to it, the ſwifter is his motion from eaſt to weſt, from north to ſouth, and from ſouth to north. He paſſes ſeven degrees, from three and a half ſouth latitude to three and a half north, in eighteen days: whereas at twenty degrees north latitude, he ſpends a whole month in going three degrees and a half, and another month in returning: ſo that he is as near the tropic for ſixty-ſeven days, as he was to the line for eighteen. And hence the heat is conſiderably greater under the tropic, than it is under the line.

5. The moon moves round the earth in about twenty-eight days, and with the earth round the ſun in a year. Yet it always turns nearly the ſame ſide to the earth, whence we always obſerve the ſame inequalities in its ſurface. It does not appear that ſhe moves at all round her own axis. None now doubts of the moon's being an opaque body: and the ſpots and uneveneſſes, which conſtantly

conſtantly appear upon it, have been judged by ſome to be vallies, mountains, lakes, and ſeas.

Her days and months are of an equal length, which we do not obſerve of any other body in the heavens. That her day is equal to her month, appears hence. Since in whatever part of her orbit ſhe is, the ſame face and the ſame ſpots are always obſerved, without the leaſt variation, ſhe muſt have ſuch a motion round her own axis as turns every moment ſo much of her ſurface from our view, as is turned to us by her periodical motion: that is, ſhe muſt move in the ſame time about her axis, as ſhe does about the earth.

Half at leaſt of the moon is always enlightened by the ſun, but as it is continually changing its ſituation, the whole of the enlightened part is not always toward us, and therefore ſhe exhibits to us various appearances. When ſhe begins to recede from her conjunction with the ſun, and to emerge out of his rays, a ſmall portion of her enlightened part is ſeen, and appears as it were horned. But the farther ſhe recedes from the ſun, the more of the enlightened part appears, till about the fourteenth day, being juſt oppoſite to him, ſhe ſhews us her entire hemiſphere. In the ſame manner ſhe appears to decreaſe, while ſhe is approaching the ſun. The moon is ſuppoſed to be forty-five times ſmaller than the earth.

The moon has ſometimes diſappeared in a clear ſky, ſo as not be diſcoverable by the beſt glaſſes. This Keppler obſerved in the year 1580 and in 1583: Hevelius in 1620, as did Ricciolus and many others at Bologna. Many people throughout Holland obſerved the ſame, April 14, 1642. December 23, 1703, there was another total obſcuration. A little before it, ſhe appeared at Arles of a yellowiſh brown, at Avignon, ruddy and tranſparent. At Marſeilles one part was ruddy, the other duſky, till ſhe wholly diſappeared. I do not find that the boldeſt philoſophers attempt to account for this.

It is now almoſt univerſally ſuppoſed, that the moon is juſt like the earth, having mountains and vallies, ſeas with iſlands, peninſulas and promontories, and

a changeable atmoſphere, wherein vapours and exhalations riſe and fall. And hence it is generally inferred, that ſhe is inhabited like the earth, and by parity of reaſon, that all the other planets, as well as the earth and moon, have their reſpective inhabitants. But after all comes the celebrated Mr. Huygens, and brings ſtrong reaſons why the moon is not and cannot be inhabited at all, nor any ſecondary planet whatever. Then I doubt we ſhall never prove that the primary are: and ſo the whole ingenious hypotheſis, of innumerable ſuns and worlds moving round them, vaniſhes into air.

It may not be unacceptable to the reader, to ſee the ſum of his reaſonings on this head. " One would think that the moon which is ſo near us, and may by a teleſcope be ſo accurately obſerved, ſhould afford us matter of more probable conjecture, than any of the remoter planets. But it is quite otherwiſe. Only this we may venture to ſay, that all the attendants of jupiter and ſaturn are of the ſame nature with our moon, as going round them, and being carried with them round the ſun, juſt as the moon is with the earth. Therefore whatever we may reaſonably affirm or conjecture, with regard to our moon, muſt be ſuppoſed with very little alteration to belong to the ſatellites of jupiter and ſaturn.

" The ſurface of the moon is found, even when we uſe the ſhorteſt teleſcopes, to be diverſified with long tracts of mountains, and again with broad vallies. For in thoſe parts oppoſite to the ſun, you may ſee the ſhadows of the mountains, and often the round vallies between them, with a hill or two riſing out of them. But I cannot find any thing like ſea there, notwithſtanding what many affirm. For thoſe vaſt countries which appear darker than the others, commonly taken for ſeas, are diſcovered with a good long teleſcope to be full of little round cavities: the ſhadow of which, falling within themſelves, makes them appear of that colour. And thoſe large champains, if you look carefully upon them, you will find, not to be always ſmooth and even. Now neither of theſe things can agree to

the

the ſea. Therefore it is far more probable, that thoſe plains in her which ſeem brighter than the other parts, conſiſt of a whiter ſort of matter. Nor do I believe, that there are any rivers: for if there were, they could never have eſcaped our obſervations. Eſpecially if they run between the hills, as our rivers do. Nor have they any clouds to furniſh rivers with water. For if they had, we ſhould ſometimes ſee one part of the moon darkened by them and ſometimes ſee one part of the moon darkened by them and ſometimes another, whereas we have always the ſame proſpect of her.

"It is certain moreover that the moon has no air or atmoſphere ſurrounding it. For then we could never ſee the outermoſt rim of the moon ſo exactly as we do when any ſtar goes under it, but its light would terminate in a faint, gradual ſhade, and there would be a ſort of down as it were about it. Not to mention, that the vapours of our atmoſphere conſiſt of water; and conſequently where there are no ſeas, there can be no ſuch atmoſphere. This is the grand difference between the moon and us. Were there ſeas and rivers therein, we might eaſily believe that it had all the other furniture which belongs to our earth. But how can plants or animals, all whoſe nouriſhment comes from liquid bodies, thrive in a dry waterleſs ſoil?

"Does then the moon ſerve for nothing but to give us light in the night? And do all theſe moons round jupiter and ſaturn, anſwer no other purpoſe? I do not know what to ſay, becauſe I know of nothing like them to found a conjecture upon. Perhaps they may have ſome plants and animals, which have ſome nouriſhment of a different kind from ours. Perhaps they may have moiſture enough to cauſe a miſt or dew, which may ſuffice for the herbs that grow there. But theſe are mere gueſſes, or rather doubts. And yet they are the beſt we can make, concerning either our moon or thoſe which attend jupiter and ſaturn."

What benefits do we receive from our moon? Firſt, the ſupplying light in the night-time, for at leaſt three fourths of the year. Now how comfortable and delightful a thing this is, travellers and voyagers can beſt tell. Curioſity, ambition, luxury, and ſometimes neceſſity

neceſſity have made it unavoidable, that ſome part of mankind ſhould be travelling by land and ſea, in the night ſeaſons. How pleaſant then is it, to have a light held out from heaven, to guide our ſteps, to direct us in our courſe, and to point out to us how our time wears out.

Secondly, ſhe raiſes our tides twice in twenty-four hours, which is abſolutely neceſſary towards the ſubſiſtence both of animals and vegetables. Every body knows that a lake that has no freſh water running into it, will by the heat of the ſun in a few months, and its ſtagnation, turn into a ſtinking, rotten puddle, ſending forth nauſeous and poiſonous ſteams. And though many thouſand rivers daily run into the ſea, yet they are very inconſiderable in reſpect of the vaſt ocean of ſalt-water; and would by no means hinder its ſtagnation, and conſequently its corruption and ſtinking. Now ſuppoſe the ocean ſtagnated, the firſt effect would be, all the places towards the ſhores, would be wrought upon by the ſun, and turned to a mephitis. Then it would get farther till the whole were become more baneful and poiſonous than the lake of Sodom and Gomorrah. Hereby the fiſhes would firſt be deſtroyed, and afterwards the plants and animals; but by this action of the moon, the waters are lifed up on a heap, as it were, and then let fall again, whereby the waters near the ſhores are conſtantly ſecured from ſtagnation and corruption, and the beginning of malady ſtifled. This perpetual change of new water on the ſhores, keeping any one portion thereof, from being expoſed to the ſun long enough to have its mixture corrupted. Now what a noble contrivance have we here. By appointing an attendant to our earth, all the animals and vegetables are preſerved from certain deſtruction. Though indeed to the full effect of this wiſe deſign, the ſalt of the ſea does very much contribute; as there are many ſaline rocks and mountains diſperſed over the foundations of the great ocean. Beſides this, how many conveniencies for our navigation in rivers and harbours does this ebbing and flowing of the ſea afford? Yet if our earth had more than one moon attending it, we ſhould receive more

damage

damage than advantage by it; for though hereby our light in the night might be augmented, yet at their conjunctions and oppoſitions with one another, and with the ſun, we ſhould have tides that would raiſe the waters over too much of our dry land; and in their quadratures we ſhould have no tide at all. Again, if our moon were bigger or nearer the earth, or if we had more than one, at any tolerable diſtance from us, we ſhould be every now and then in hazard of being ſtifled by the noxious ſteams ariſing from the ocean. From all which it is evident, how wiſely our ſatellite has been contrived for our purpoſes.

6. Mars, as well as venus, mercury, and the moon, has various appearances, more or leſs full, as it is variouſly placed, with regard to the ſun and the earth. Spots are obſerved on his ſurface alſo, from the regular motion of which we learn, that he revolves round his axis from weſt to eaſt, in twenty-four hours and forty minutes. He moves round the ſun in two years, and it is thought to be eight times ſmaller than the earth.

7. Jupiter is encompaſſed from weſt to eaſt with two or three lucid belts, not always appearing alike. In one of them a ſpot is conſtantly obſerved; and they regularly move from weſt to eaſt. Hence we learn, that he revolves round his axis, which he does in nine hours and fifty-ſix minutes. He is likewiſe attended by four ſmaller planets or ſatellites, like our moon. Each of theſe move round him in its ſtated period, and all move with him round the ſun in twelve years. Jupiter is ſuppoſed by ſome to be twenty-five, by others 4096 times larger than the earth.

8. The higheſt planet, ſaturn, is encompaſſed with a broad ring, which is not contiguous to his body, but is ſuſpended over him equally diſtant from every part of his ſurface. He has five ſatellites or moons, moving round him in their ſtated periods. The brighteſt of theſe, which is the fourth, was firſt diſcovered by Mr. Huygens, in the year 1655. The reſt were diſcovered by Caſſini. And I have reaſon to think, ſays Mr.

Mr. Huygens, there are one or two more ſtill behind. For between the fourth and fifth there is a diſtance not at all proportionable to that between all the others. Hence it is probable there may be a ſixth. And there may not improbably be another, without the fifth, which has hitherto eſcaped us. For we can never ſee the fifth but in that part of its orbit, which is towards the weſt.

Saturn himſelf revolves with them round the ſun in about thirty years. He is ſuppoſed to be fifteen times bigger than the earth.

If we compute the magnitude of the planets in number of miles, the diameter of the moon is ſuppoſed to be 2175 miles, that of mercury 2748, that of mars 4875, of the earth, (and nearly of venus) 7967, of ſaturn 93451, of jupiter 130653; and that of the ſun 822148.

With regard to their diſtance from the earth, there is ſuch an immenſe difference in the calculations of aſtronomers, even with reſpect to the diſtance of the ſun (which ſome demonſtrate to be ninety millions of miles, others to be not three millions from the earth;) that it is the wiſeſt to confeſs our ignorance, and to acknowledge we have nothing to reſt on here but mere uncertain conjecture.

9. Comets are opaque bodies, which emit numerous rays, ſometimes forwards, ſometimes backwards, ſometimes all round the body of the comet. Now they ſink near the body of the ſun: then they riſe far beyond the orb of ſaturn. Some ſuppoſe them to be imperfect planets, or ſuch a chaos of unformed matter, as may hereafter be formed into an earth like ours. Probably thoſe rays which they emit, are only vapours, by which the rays of the ſun are refracted to us.

Hence they have a different appearance, according as they are differently ſituated with regard to the comet: the nearer they are to the ſun, the more thoſe rays are increaſed, and the farther they recede from it, the more thoſe are diminiſhed. And hence ſome imagine that fixed ſtars, covered with vapours and ſpots, become comets. It is more probable that comets, like planets have their regular periods: although they frequently

quently eſcape our obſervations, as not revolving but in a long term of years.

They are diſtinguiſhed from other ſtars by a large train of light, which is always oppoſite to the ſun, and grows fainter and fainter the farther it is from the body of the comet. When a comet moves from the ſun it is ſaid to be bearded, becauſe that light is ſeen before it. When it moves toward the ſun, the train follows it, and is called its tail. When the comet and ſun are oppoſite, (the earth being between them) the train is hid behind the body of the comet, except a little that appears round it, and is termed its hair.

Sir Iſaac Newton has proved, that the heat of the ſun to the comet in December 1680, was to his heat with us at midſummer, as 28000 to one: and that the heat of the body of the comet was near 2000 times greater than that of red-hot iron.

After having acquired ſo immenſe a heat, it muſt be a long time in cooling. Sir Iſaac computes, that a globe of red-hot iron 200 times as large as the earth, would ſcarce be cool in 50,000 years. If then the comet be ſuppoſed to cool a hundred times as faſt as red-hot iron, yet ſince its heat was two thouſand times greater, ſuppoſing it of the bigneſs of the earth, it would not be cool in a million of years.

Comets ſeem to be a peculiar kind of planets, which move in very oblique orbits, and perſevere in their motions, even againſt the courſe and direction of the other planets. Their tails are doubtleſs vapours emitted by the comet when heated by the ſun. Yet they do not aſcend ſwiftly from it, and then preſently diſappear; but are permanent columns of exhalations, gathered from the comet by a gentle motion, and in a great ſpace of time, which then move with it through the celeſtial regions.

One great uſe of comets probably is, to give moiſture to the planets. By their vapours the water ſpent in them, may be ſupplied and recruited. All vegetables grow from fluids. But when they putrefy, great part of them turn into dry earth: hence the quantity

of

of dry earth muſt continually increaſe, and the moiſture of the globe decreaſe. Add to this, that immenſe quantities of watry vapours, are continually arreſted in the polar regions, and falling down form mountains of eternal ſnow, and rocks of ice that thaw no more. By both theſe means the moiſture of the planets continually decreaſing, muſt in proceſs of time, entirely fail, if it had not a ſeaſonable ſupply, from ſome other part of the univerſe. Comets therefore are ſo far from being ſuperfluous, much more from being blemiſhes in the univerſe, that it may be doubted whether either the animals or vegetables of the earth could long ſubſiſt without them.

And indeed, if the uſes aſſigned to the comets by Sir Iſaac Newton be real, as they are not improbable, namely the ſupplying the deficiency and expenſes of all ſorts of fluids neceſſary to the earth: I mean not only light and heat to the ſun, and watry vapours to our atmoſphere, but the moſt ſubtle, moſt uſeful, and neceſſary part (towards life and vegetation) to the air; then theſe wandering, frightful bodies may be juſtly conceived joining in the chorus, and loudly reſounding the common hallelujah.

But the aſtronomy of comets, ſays Mr. Brydon is clogged with very great difficulties, and even ſome ſeeming abſurdities. It is difficult to conceive, that theſe immenſe bodies, after being drawn to the ſun, with the velocity of a million of miles in an hour, when they have at laſt come almoſt to touch him, ſhould then fly off from his body, with the ſame velocity they approached it, and that too, by the power of this very motion, that his attraction has occaſioned. The demonſtration of this, I remember is very curious and ingenious; but I wiſh it may be entirely free from ſophiſtry. No doubt, in bodies moving in curves round a fixed centre, as the centripetal motion increaſes, the centrifugal one increaſes likewiſe: but how this motion which is only generated by the former, ſhould at laſt get the better of the power that produces it, and that too, at the very time this power has acquired its utmoſt force and energy, ſeems ſomewhat difficult to conceive. It is the only inſtance I know, wherein the

effect

effect increaſing regularly with the cauſe; at laſt, whilſt the cauſe is ſtill acting with full vigour, the effect entirely gets the better of the cauſe, and leaves it in the lurch. For the body attracted, is at laſt carried away with infinite velocity from the attracting body. By what power is it carried away? Why, ſay our philoſophers, by the very power of this attraction, which has now produced a new power ſuperior to itſelf: to wit, the centrifugal force. However, perhaps all this may be reconcileable to reaſon; far be it from me to preſume to attack ſo glorious a ſyſtem as that of attraction. The law that the heavenly bodies are ſaid to obſerve, in deſcribing equal areas in equal times, is ſuppoſed to be demonſtrated, and by this it would appear, that the centripetal and centrifugal forces alternately get the maſtery of one another.

However, I cannot help thinking it ſomewhat hard to conceive, that gravity ſhould always get the better of the contrifugal force, at the very time that its action is the ſmalleſt, when the comet is at the greateſt diſtance from the ſun; and that the centrifugal force ſhould get the better of gravity, at the very time that its action is the greateſt, when the comet is at its neareſt point to the ſun.

To a common obſerver it would rather appear, that the ſun, like an electric body, after it had once charged the objects that it attracted, with its own effluvia or atmoſphere, by degrees loſes its attraction, and at laſt even repels them, and that the attracting power, like what we likewiſe obſerve in electricity, does not return again till the effluvia imbibed from the attracting body are diſpelled or diſſipated; when it is again attracted, and ſo on alternately. For it (appears at leaſt to an unphiloſophical obſerver) ſomewhat repugnant to reaſon, to ſay, that a body flying off from another body ſome thouſands of miles in a minute, ſhould all the while be violently attracted by that body: and that it is even by virtue of this very attraction that it is flying off from it. He would probably aſk, what more it could do, pray, were it really to be repelled?

Had the ſyſtem of electricity, and of repulſion, as well as attraction, been known and eſtabliſhed in the laſt age, doubtleſs the profound genius of Newton would

would have called it to his aid, and perhaps accounted in a more ſatisfactory manner for many of the great phenomena of the heavens.

To the beſt of my remembrance, we know of no body that poſſeſſes, in any conſiderable degree, the power of attraction, that in certain circumſtances does not likewiſe poſſeſs the power of repulſion: the magnet, the tourmalin, amber, glaſs, and every electrical ſubſtance. Now from analogy, as we find the ſun ſo powerfully endowed with attraction, why may we not likewiſe ſuppoſe him to be poſſeſſed of repulſion? Indeed this very power ſeems to be confeſſed by the Newtonians, to reſide in the ſun in a moſt wonderful degree; for they aſſure us he repels the rays of light with ſuch amazing force, that they fly upwards of 80 millions of miles in 7 minutes. Now why ſhould we confine this repulſion to the rays of light only? As they are material, may not other matter brought near his body, be affected in the ſame manner? Indeed one would imagine, that their motion alone would create the moſt violent repulſion; and that the force with which they are perpetually flowing from the ſun, would moſt effectually prevent every other body from approaching him; for this we find is the conſtant effect of a rapid ſtream of any other nature. But let us examine a little more his effects upon comets. The tails of theſe bodies are probably their atmoſpheres, rendered highly electrical, either from the violence of their motion, or from their proximity to the ſun. Of all the bodies we know, there is none in ſo conſtant and ſo violent an electrical ſtate, as the higher regions of our own atmoſphere. Of this I have long been convinced; for ſend up a kite with a ſmall wire about its ſtring, only to the height of twelve or thirteen hundred feet, and at all times it will produce fire, as I have found by frequent experience; ſometimes when the air was perfectly clear, without a cloud in the hemiſphere; at other times, when it was thick and hazy, and totally unfit for electrical obſervations below. Now as this is the caſe at ſo ſmall a height, and as we find the effect ſtill grows ſtronger in proportion as the kite advances (for I have ſometimes obſerved that a little blaſt of wind, ſuddenly

denly raiſing it about a hundred feet, has more than doubled the effect) what muſt it be in very great elevations? Indeed we may often judge of it from the violence with which the clouds are agitated, from the meteors formed above the region of the clouds, and particularly from the aurora borealis, which has been obſerved to have much the ſame colour and appearance as the matter that forms the tails of comets.

There is a ſpecies of comets, ſays the ſame gentleman, that have not tails: theſe are certainly bodies of a very different nature from thoſe with tails, to which indeed they appear even to bear a much leſs reſemblance than they do to planets: and it is no ſmall proof of the little progreſs we have made in the knowledge of the univerſe, that they have not as yet been diſtinguiſhed by a different name.

This is the third kind of body that has been diſcovered in our ſyſtem, that all appear eſſentially different from each other, that are probably regulated by different laws, and intended for very different purpoſes. How much will poſterity be aſtoniſhed at our ignorance, and wonder that this ſyſtem ſhould have exiſted for ſo many thouſand years, before we were in the leaſt acquainted with one half of it, or had even invented names to diſtinguiſh its different members.

I have no doubt, that in future ages the number of the comets, the form of their orbits, and time of their revolutions, will be as clearly demonſtrated, as that of the planets. It is our countryman Dr. Halley, who has begun this great work, which may be conſidered juſt now as in its earlieſt infancy. Theſe bodies too, with thick atmoſpheres, but without tails will likewiſe have their proper places aſcertained, and will no longer be confounded with bodies to which they bear no reſemblance or connection.

Comets with tails have ſeldom been viſible, but on their receſs from the ſun. It is he that kindles them up, and gives them that alarming appearance in the heavens. On the contrary, thoſe without tails, have ſeldom, perhaps never, been obſerved but on their approach to him. I do not recollect any whoſe return

has

has been tolerably well aſcertained. I remember indeed, a few years ago a ſmall one, that was ſaid to have been diſcovered by a teleſcope, after it had paſſed the ſun, but never more became viſible to the naked eye. This aſſertion is eaſily made, and nobody can contradict: but it does not at all appear probable, that it ſhould have been ſo much leſs luminous after it had paſſed the ſun, than before it approached him; and I will own, when I have heard that the return of theſe comets had eſcaped the eyes of the moſt acute aſtronomers, I have been tempted to think that they did not return at all, but were abſorbed in the body of the ſun, which their violent motion toward him ſeemed to indicate. Indeed, I have often wiſhed that this diſcovery might be made, as it would in ſome meaſure account for what has as yet been looked upon as unaccountable; that the ſun, notwithſtanding his daily waſte from enlightening the univerſe, never appears diminiſhed either in ſize or light. Surely this waſte muſt be immenſe, and were there not in nature ſome hidden proviſion for ſupplying it, in the ſpace of ſix thouſand years, (ſuppoſing the world to be no older) the planets muſt have got to a much greater diſtance from his body, by the vaſt diminution of his attraction: they muſt likewiſe have moved much ſlower, and conſequently the length of our year muſt have been increaſed. Nothing of all this ſeems to be the caſe: he neither appears diminiſhed, nor our diſtance from him increaſed; his light, heat, and attraction ſeem to be the ſame as ever; and the motion of the planets round him is performed in the ſame time; of conſequence, his quantity of matter ſtill continues the ſame. How then is this vaſt waſte ſupplied? May there not be millions of bodies attracted by him from the boundleſs regions of ſpace, that are never perceived by us? Comets on their road to him, have ſeveral times been accidentally diſcovered by teleſcopes that were never ſeen by the naked eye. Indeed the number of black ſpots on the ſun, ſeems to indicate, that there is always a quantity of matter there only in preparation to give light, but not yet refined and pure enough to throw off rays like the reſt of his body. For I think we can hardly conceive, that any matter can remain long on the body of

the

the ſun without becoming luminous; and ſo we find theſe ſpots often diſappear; that is to ſay, the matter of which they are compoſed is then perfectly melted, and has acquired the ſame degree of heat and light as the reſt of his body. Even in glaſs houſes, and other very hot furnaces, moſt ſorts of matter very ſoon acquire the ſame colour and appearance as the fire, and emit rays of light like it. But how much more muſt this be the caſe at the ſurface of the ſun? When Newton computes, that even at many thouſand miles diſtance from it, a body would acquire a degree of heat two thouſand times greater than that of red hot iron, It has generally been underſtood, that he ſaid the great comet really did acquire this degree of heat: but this is certainly a miſtake: Sir Iſaac's expreſſion, to the beſt of my remembrance, is, that it might have acquired it. And if we conſider the very great ſize of that body, and the ſhort time of its perihelion, the thing will appear impoſſible; nor indeed do I think we can conceive that a body only as large as our earth, (and the ſpots on the ſun are often much larger,) could be reduced to fuſion even on his ſurface, but after a conſiderable ſpace of time.

Now it ſeems to be univerſally ſuppoſed, that the rays of light are really particles of matter, proceeding from the body of the ſun. If ſo it is abſolutely neceſſary that we ſhould fall upon ſome ſuch method of ſending him back a ſupply of thoſe rays, otherwiſe let his ſtock be ever ſo great, it muſt be exhauſted.

10. It is commonly ſuppoſed, that the fixed ſtars are ſo many ſuns, ſhining with their own light: and that each of them has a ſet of planets moving round it: as the earth, and the other planets do round our ſun. It may be ſo, or it may not; for we know nothing about them: nor is it poſſible we ſhould know more. For even when viewed with the beſt teleſcopes, they appear no larger than they do to the naked eye. They are divided, according to their ſize, into ſtars of the firſt, ſecond, and ſo on to the ſixth magnitude.

Even a good eye ſeldom ſees more than a hundred ſtars, at a time in the cleareſt heaven. The appearance of vaſt numbers in winter nights, is a mere deception

ception of our ſight, occaſioned by our viewing them confuſedly, not in any regular order.

Yet are they really almoſt infinite. For a good teleſcope directed to almoſt any part of the heavens, diſcovers numbers unſeen by the naked eye, particularly in the milky way: which is indeed nothing elſe but an aſſemblage of ſtars, too remote to be ſeen ſingly, but ſo cloſe to each other, as to give that brightneſs to ſo large a part of the heavens.

There are ſix or ſeven of theſe nebulous ſtars, as they are called. They are indeed compound ſtars, conſiſting of multitudes of ſingle ones. In ſome of theſe appears a bright lucid part, in which ſome ſtars appear, as from a white cloud, and theſe are reckoned to be regions of a peculiar nature, enjoying an uninterrupted, everlaſting day.

The ſeven ſtars ſo called, probably were ſeven once; but one of them became extinct, even before the time of Auguſtus Cæſar: and no more than ſix have appeared ever ſince. But theſe likewiſe, when viewed through a good teleſcope, are more than can eaſily be numbered.

A hundred and twenty-five years before Chriſt, Hipparchus diſcovered a new ſtar. In 1572 Tycho Brache obſerved another. Its magnitude at firſt exceeded the biggeſt of our ſtars. It equalled that of venus when neareſt the earth, and was ſeen in fair day light. It continued ſixteen months, toward the end of which it grew leſs till it totally diſappeared. We have an account of one appearing at leaſt thrice before, at the interval of 150 years. Probably it was the ſame ſtar, and will return at the ſtated time.

Many other new ſtars have been obſerved in this century to appear and diſappear; and it is certain from the old catalogues, that many of the ancient ſtars are not now viſible.

There are now wanting two ſtars of the ſecond magnitude in the ſhip Argo, which were ſeen till the year 1664. But there was not the leaſt ſign of them in

1668.

1668. Accurate aſtronomers have obſerved many more ſuch changes in the fixed ſtars, to the number of a hundred.

Are theſe temporary ſtars a ſort of planets? Are they fixed ſtars, which being covered with ſpots like thoſe obſerved on the ſun, loſe their brightneſs, and conſequently diſappear? Or are they comets, which take ſo vaſt a time to perform their revolutions, as ſeldom to have their returns perceived?

11. It remains only to make ſome improvement of what has been obſerved, concerning the ſyſtem of the univerſe. And firſt, we may obſerve the due ſituation of the heavenly bodies. 1. None of them interfere with each other. Had the univerſe been the work of any but the wiſe architect, there would have been many inconveniences in the ſituation of ſuch a prodigious number of immenſe globes. Some would have been too near or too far off; ſome would have incommoded others. But inſtead of this, all the globes which fall under our notice, are ſet at ſuch a due diſtance, as not only to avoid all violent concourſe, but not to ſhade each other, ſo as to hinder each other's kindly influence, or to occaſion noxious ones. 2. As it is one great inſtance of the ſkill of an architect, to give due proportion to his works, ſo this abundantly appears in all the heavenly bodies that come under our cognizance. Curious order, and due and nice proportions are obſerved in their ſituations. The ſun is placed in the centre of his ſyſtem, to give all his planets heat and light. Then follow the ſeveral planets ſurrounding him, not ſcattered at all adventures, but at due diſtances from the ſun, as well as from one another. And this is diſcernible, not only in the primary, but the ſecondary planets too: in the five moons that attend ſaturn, and the four that accompany jupiter.

The wiſdom of the Creator appears, ſecondly from the motions of the heavens and the earth. That theſe vaſt globes ſhould move at all, proves ſome being that has power to put them in motion: ſeeing matter cannot move itſelf. And ſuppoſe them moved by the ſun, the ether, or ſome other primary mover, ſtill we muſt

recur

recur to ſome firſt cauſe who was able to put the mover into motion. And this could be no other than the hand of the Almighty. What farther ſhews both his power and wiſdom, is, that thoſe motions are not at random, or in inconvenient lines and orbs, but ſuch as manifeſt the deepeſt counſel. That every planet ſhould have as many and various motions, as the world and its inhabitants have occaſion for, muſt be the work of a wiſe and kind, as well as omnipotent Creator.

In particular, the diurnal motion of theſe globes ſhews the wiſdom of the Creator. Of what prodigious uſe is this? Were the planets always to ſtand ſtill, half of each globe would be dazzled and parched with unceaſing day, and the other half wrapt in everlaſting darkneſs. Were this the caſe with our globe, a great part of it at leaſt would ſcarce be habitable. It would neither agree with the ſtate of man or other animals, nor of vegetables. How could the vapours be raiſed to ſupply the earth with cooling clouds and fruitful ſhowers? How could the winds be excited to fan the atmoſphere with their pleaſant and healthful gales? How could vegetables be raiſed up by the kindly heat of the day, and tempered by the dews and cool of the night? How could men and other animals gather their food, and perform the various labours of the day, and then under the ſalutary influences of the night recruit themſelves with reſt and ſleep?

And as the diurnal, ſo the annual motion of the heavenly bodies, is a clear manifeſtation of the Creator's wiſdom: eſpecially when we conſider the different paths of their diurnal and annual motions. Theſe lie not in a very different plane, nor in the ſame, but a little croſſing one another: the diurnal lying in or parallel, to the equator, the annual, at an inclination of twenty-three degrees and a half. A glorious contrivance this for the good of our globe, and for all the reſt that have the ſame annual motion. For were the earth's annual motion to be always in the ſame plane with the diurnal, we might indeed be ſometimes nearer to the ſun than we now are. But we ſhould miſs of thoſe kindly increaſes of day and night, which the approach

proach of earth to one or the other pole occaſions. This is likewiſe the great cauſe of ſummer and winter. Indeed one cauſe of them is, the longer or ſhorter continuance of the ſun above the horizon. As it continues longer in ſummer, it increaſes the heat, as much as it lengthens the day: and juſt the contrary in winter. But the chief cauſe is, the oblique or perpendicular direction of the ſun's rays. For 1. Perpendicular rays ſtrike on any plane, with greater force than oblique. And 2. A greater number of rays fall within the ſame compaſs, in a perpendicular than in an oblique direction.

A farther manifeſtation of the Creator's wiſdom we have in the perpetuity, conſtancy, and regularity of thoſe motions. How without an Almighty guide ſhould thoſe vaſt bodies continue their courſes throughout all ages? How ſhould they perform their uſual ſtages, without the leaſt intermiſſion or diſorder? What piece of clock-work under heaven, was ever comparable to this? How ſteadily do all theſe motions conſpire, to anſwer the ends of Divine Providence, to diſpatch the noble offices of the ſeveral globes, to comfort and cheriſh every thing reſiding on them, by the uſeful change of day and night, and the ſeveral ſeaſons of the year.

We may learn the wiſdom of God, thirdly, from the figure of the heavenly bodies, ſo well ſuited to the motions, and to the whole ſtate and convenience of them. And 1. They are all nearly ſpherical: I ſay, nearly, to allow for their difference between their polar and equatorial diameter. Now this figure is both more capacious than any other, and more agreeable to a maſs in motion, each part of it being at a due diſtance from the centre of motion and gravity: beſides, without this, there could have been no ſuch agreeable alterations of day and night, of heat and cold. And as to our own globe, the winds could not have fanned the air, as now, but muſt have been greatly retarded, if not wholly ſtopt, by the angles and jettings out of other figures. Laſtly, the waters would have had intolerable confluences; here too much, there none at all. So

that inſtead of a habitable world, far the greateſt part would have been a deſert, or an uſeleſs bed of waters.

And all the parts of the earth are ſo diſtributed as may beſt miniſter to their ſeveral uſes. Thus the two grand parts, the ſolids and fluids, inſtead of being jumbled into one maſs, are admirably parted, and as nicely diſpoſed of in proper places. The ſtrata conveying ſweet water in all or moſt parts of the world, conſiſt of proper, pervious matter, remain diſtinct from the other ſtrata, and lie at ſuch due depths, as either to break out in fountains, or to be dug into for wells: all which is a manifeſt demonſtration of the concern of a wiſe agent.

And not only the planets are a demonſtration of this, but the very comets alſo: though their motions are ſo far from being always the ſame way, that they move ſometimes contrary to each other. Their planes and directions lie every way, and their orbits are exceeding eccentrical. But this very eccentricity is an admirable contrivance of the Creator, to prevent their diſturbing either the planets, or one another, by mutual attractions. By this means they have ſufficient room to revolve in: and by aſcending to very great heights, and ſpending almoſt their time in the remote regions of the univerſe, at vaſt diſtances both from the planets and each other, they incommode neither. Whereas had they moved in the ſame plane with the planets, they would ſometimes have come too near them: and poſſibly have diſturbed their motions, or even daſhed againſt them.

But what would all the planets have done, had they not been ſupplied with light and heat? And what an indulgent proviſion of theſe is made even for the moſt diſtant of them? See the ſun, ſuch a prodigious maſs of fire, placed in the centre of the ſyſtem, to ſcatter his light throughout the whole, and to warm and cheriſh us by day: and ſuch a noble retinue of moons and ſtars, attending and aſſiſting us by night! And we ſee the ſame care of the Creator, extended to all the other planets. According to their ſeveral diſtances,

they

they have proportionably a great number of moons, and ſaturn a ſtupendous ring beſides, to ſupply the decreaſe of light and heat. Who can help being amazed at ſuch well-contrived, ſuch ſtately works of God? Who can partake of their beneficial influences, and not adore the wiſdom and kindneſs of their Maker?

One or two points, which have been lightly mentioned already, deſerve a more particular conſideration.

That he who diſpenſes exiſtence at his will, ſhould multiply, extend, enlarge, and add a kind of immenſity to his works, is not properly what ſurpriſes me; at leaſt my amazement is chiefly founded on my own littleneſs. But what aſtoniſhes me moſt, is to ſee, that notwithſtanding this my extreme littleneſs, he has vouchſafed to regulate his immenſe works, by the advantages I was to receive from them! Thus he has placed the ſun juſt at ſuch a diſtance from the earth on which I was lodged, that it might be near enough to warm me, yet not ſo near, as to ſet it on fire.

The rays that proceed from a globe of fire, many thouſand times bigger than the earth, muſt needs have an inconceivable force, while they remain cloſe to each other. But they are more and more diſtant from each other, as they advance from their common centre, toward the vaſt circumference they are to enlighten, and their force diminiſhes in proportion. Had the earth been placed where theſe rays were ſtill too numerous, and too near each other, it could never have borne their burning heat. Had it been placed farther off than it is, it would have received but a faint warmth, ſuch as would be inſufficient for its uſual productions. It ſtands in that very place where it is ſecured from all theſe inconveniences, and within the reach of every advantage.

The heavens declare the grandeur and glory of God, from one end of the world to the other. But the ſun alone affects us more than all the beauties the heavens

can diſplay to our ſight: the heavens are only a pavillion to the ſun. The richly embroidered veil which ſeemed to hide him from us for a ſeaſon, is removed, when he advances. At firſt, he appears as a young bridegroom, coming out of his chamber. His ſplendor is then full of mildneſs, and he is eaſy of acceſs. But he is commiſſioned to convey the heat and the life, as well as the light, every where. He darts more and more fire as he aſcends. He paſſes from one end of the heavens to the other. There is nothing can either be hid from his light, or ſubſiſt without his heat. And by his penetrating fires he reaches thoſe very places which are inacceſſible to his rays.

And yet we need his abſence at proper intervals, no leſs than we do his preſence. For night and ſleep are ſo connected, that when we want repoſe, we generally procure a kind of artificial night. Our ſenſes are ſeldom unbent, but by the removal of that which agitates them. And this is the ſervice for which night is appointed, and which it excellently well performs. It does not come in a blunt and abrupt manner, to extinguiſh the light of the day, and all on a ſudden to rob us of the ſight of the objects we are intent on: but advances only by ſlow ſteps, and brings on darkneſs by degrees. It is not till after reminding us of the neceſſity of taking reſt, that it covers the face of nature.

During the time of man's repoſe, night huſhes every noiſe. It indeed ſuffers a few animals, whoſe grim aſpect might ſcare him, to go forth, and ſilently ſeek their food. It permits however, the animal that ſtands ſentinel by him, to give him notice of what concerns him. But it keeps the horſe, the ox, and all his domeſtics faſt aſleep around him. It diſperſes the birds, and ſends each to his reſpective abode. As it comes on, it gradually huſhes the winds, to ſecure the lord of nature's reſt. It cauſes his repoſe to be reverenced every where: the moment of which is no ſooner come, but all creatures retire, and for ſeveral hours, an univerſal ſilence reigns.

Nor

Nor yet is nature's palace wholly void of light. As ſome may be conſtrained to travel by night, ſeveral flambeaus are ſcattered through the firmament. But theſe, though they prevent total darkneſs, yield only a gentle light. Nor ought thoſe who then wake to be ſupplied with ſuch a light, as would interrupt the repoſe of others.

But it is not by its darkneſs only, that night is uſeful to us. Its coolneſs likewiſe is of uſe: and this increaſing the ſpring of the air, makes it capable of working with greater activity, and giving new vigour both to the dry plants and the enfeebled animals. It is to preſerve this cool, that the moon reflecting the light of the ſun, gives it without any ſenſible heat. In vain do we collect her rays by the ſtrongeſt burning glaſs. An admirable caution of the Divine Artificer, who has reſerved for the night ſeaſon, a light ſtrong enough to remove darkneſs, yet too weak to alter the coolneſs of the air.

When man is inclined to have the benefit of this, he ſees no more the proſpects of the day; but night in her turn, favours him with another, that has charms to itſelf.

We cannot doubt but theſe immenſe globes of fire, which enlighten our night, have all their peculiar appointments, which anſwer, in God's purpoſes, the magnificence of their appearance. But who ſhall preſume to explain, what the Almighty has thought fit to conceal? The ſmall glimpſes which a few are permitted to have, being quite unknown to the bulk of mankind. It is not in the particular deſtination of each ſtar, nor in the general harmony of all, that we are to look for the means of inſtructing man, or regulating his affections. But yet what we do ſee, and know concerning them, is matter for the deepeſt admiration. We ſee innumerable fires hung up in the magnificent ceiling of our abode: and the dark azure which ſerves them as a ground, ſtill heightens their beauty and brightneſs. But their rays are diſperſed through ſpaces ſo immenſe,

that

that when they come to us, they are quite deſtitute of heat. Thus by the Creator's providence we enjoy the ſight of a multitude of fiery globes, without any danger of deſtroying the coolneſs of our night, or the quiet of our repoſe.

The ſum of what has been ſaid, with ſome farther improvements, I add in the words of Mr. Hervey.

"The earth is, in fact, a round body, though in ſome parts raiſed into hills, or ſunk into vallies, in others ſpread out into wide and immeaſurable plains. For the loftieſt mountains bear no more proportion to the whole ſurface of the ball, than a particle of duſt on the aſtronomer's globe, bears to its whole circumference. We may fancy that it has deep foundations, and reſts on ſome ſolid baſis. But it is pendent in the wide tranſparent ether, without any viſible ſupport either from above or beneath. It may ſeem to remain ſtill and motionleſs: but it is continually ſailing through the depths of the ſky, and in the ſpace of twelve months finiſhes the mighty voyage. This periodical rotation produces the ſeaſons, and completes the year. And all the time it proceeds in its annual circle, it ſpins upon its own centre, and turns its ſides alternately to the great fountain of light. By this means the day dawns in one hemiſphere, while the night ſucceeds in the other. Without this expedient, one part of its regions, would during half the great revolution, be ſcorched with exceſſive heat, and languiſh under an uninterrupted glare: while the other would be frozen to ice, and buried under diſmal and deſtructive darkneſs.

"The earth in the revolution which it performs daily on its own axis, whirls about the rate of above a thouſand miles an hour. What an amazing force muſt be requiſite, to protrude ſo vaſt a globe, and wheel it on, loaded with huge rocks and mountains, with ſuch a prodigious degree of rapidity!

"Mean time the ſun which ſeems to perform its daily

daily ſtages, is fixed and immoveable. It is the great axle of heaven, about which the earth and many large orbs wheel their ſtated courſes. And ſmall as it ſeems, it is far larger than the earth: Sir Iſaac Newton ſuppoſes, 900,000 times. Are we ready to cry out, how mighty is the being who kindled ſuch a prodigious fire? And keeps alive from age to age, ſuch an enormous maſs of flame? And yet this ſun, with all its attendant planets, are but a very ſmall part of that grand machine, the univerſe. Every ſtar is really a vaſt globe, like the ſun in ſize and in glory. Nay, every ſtar as ſome ſuppoſe, is not barely a world, but the centre of a magnificent ſyſtem; has a retinue of worlds enlightened by its beams, and revolving round its orb: all which are loſt to our ſight, in immeaſurable wilds of ether.†

"But could you ſoar farther yet, could you wing your way to the higheſt apparent ſtar, you would there ſee other ſkies expanded, another ſun diſtributing his beams by day, with other ſtars, that gild the horrors of the alternate night: and other, perhaps nobler, ſyſtems eſtabliſhed, through the boundleſs dimenſions of ſpace. Nor does the dominion of the great Sovereign, terminate even here. Even at the end of this vaſt tour, you would find yourſelf advanced no farther than the ſuburbs of creation: arrived only at the frontiers of the great Jehovah's kingdom.

"Think on this. When innumerable bodies, many of them more than a hundred thouſand miles in diameter, are ſet in motion: when the orbits in which they move are extended, to hundreds of millions of miles: when each has a diſtinct and ſeparate ſphere, for finiſhing his vaſt circuit: when none is cramped, but each freely expatiates in his unbounded career: when every one is ſo immenſely diſtant from the others that they appear each to other, as only ſo many ſpots of light: how aſtoniſhing is the expanſe which yields

† All this is spoken on the Newtonian hypothesis.

room

room for them all, and their widely diffuſed operations! To what lengths did the Almighty Builder ſtretch his line, when he marked out the ſtupendous platform! I wonder at ſuch an immeaſurable extent: my thoughts are loſt in this abyſs of ſpace.

" To go one ſtep farther ſtill: when I contemplate thoſe ample and amazing ſtructures, erected in endleſs magnificence, over all the ethereal plains: when I look on them as ſo many repoſitories of light, or fruitful abodes of life: when I remember there are orbs vaſtly more remote, than thoſe which appear to our unaided ſight: when I ſtretch my thoughts to the innumerable orders of beings, which inhabit all thoſe ſpacious ſyſtems, from the higheſt ſeraph to the puny nations that tinge the plumb with blue, or mantle the ſtanding pool with green. How various are the links in this immenſe chain, the gradations in this univerſal ſcale of exiſtence! Yet all theſe are the work of God's hand, and are full of his preſence!

" He rounded in his palm thoſe dreadfully large globes, which are pendulous in the vault of heaven. He kindled thoſe aſtoniſhingly bright fires, which fill the firmament with a flood of glory. By him they are ſuſpended in fluid ether, and never can be ſhaken: by him they diſpenſe a perpetual tide of beams, and never are exhauſted. He formed that exquiſitely fine collection of tubes, that unknown multiplicity of ſubtle ſprings, which organize and actuate the frame of the minuteſt inſect. He bids the crimſon current roll, the vital movements play, and joins together a world of wonders, even in an animated point. For there are living creatures abundantly ſmaller than a mite. Mr. Bradly mentions ſome, which by computation he found to be a thouſand times leſs than the leaſt viſible grain of ſand: at the ſame time he declares, that this was a bulky being, compared to others diſcovered by Mr. Lewenhoek. If then we conſider the ſeveral limbs, which compoſed ſuch an organized particle: the different ſprings which actuate thoſe limbs; the flow of ſpirits which put thoſe ſprings in motion; the various

fluids

fluids which circulate; the different ſecretions which muſt neceſſarily be performed; together with the proportionable minuteneſs of the ſolids, before they arrive at their full growth: we ſhall ſee the utmoſt reaſon to own, that the Creator is greatly glorious even in his ſmalleſt works.

"To conclude this head. If the ſtars are magazines of fire, and immenſe reſervoirs of light, undoubtedly they have ſome grand uſes, ſuited to the magnificence of their nature. To determine what uſes, is not poſſible, in our preſent ſtate of diſtance and ignorance. This however is clear, they are diſpoſed in ſuch a manner, as is moſt pleaſing, and ſerviceable to mankind. They are not placed at ſuch an infinite remove, as to lie beyond our ſight: neither are they brought ſo near to our abode, as to annoy us with their beams."

12. A year or two after the preceding volumes were publiſhed, the little ſketch of aſtronomy therein given, (or rather my doubts concerning it) was warmly attacked in the London magazine. The ſubſtance of thoſe objections, and of my anſwer, I have here ſubjoined.

SIR;

I am obliged to you for your queries and remarks; and ſo I ſhall be to any who will point out any thing wherein they think I have been miſtaken. It would not be ſtrange, if there ſhould be many miſtakes in the "Compendium of Natural Philoſophy:" as philoſophy is what for many years I have only looked into at leiſure hours. Accordingly in the preface of that treatiſe I ſaid, "I am thoroughly ſenſible, there are many, who have more ability, as well as leiſure, for ſuch a work than me. But as none of them undertakes it, I have myſelf made ſome little attempt in the following volumes."

Q. 1. "You ſay, the ſun is ſuppoſed to be abun-

dantly larger than the earth. Is it not demonſtrable that he is ſo?"

I do not know whether it is, or no.

Q. 2. "Why do you ſay, the moon is ſuppoſed to be forty-five times ſmaller than the earth, when the moon's bulk is nicely known?"

It is not known by me, nor, I doubt, by any man elſe.

Q. 3. "You ſay, Jupiter is ſuppoſed to be twenty-five times larger than the earth: and in the next page, that his diameter is ſuppoſed to be 130,655 miles. If ſo, is he not 4096 times larger than the earth?"

Undoubtedly. But I do not undertake to defend either one ſuppoſition or the other.

Remark 1. "You ſay, p. 148. Even with reſpect to the diſtance of the ſun, it is wiſeſt to confeſs our ignorance, and to acknowledge we have nothing to reſt upon here, but mere uncertain conjectures."

I did not ſay this of the diſtance of the ſun in particular. My words, p. 146 are, "With regard to their diſtance from the earth, (the diſtance of all the bodies in the ſolar ſyſtem) there is ſuch an immenſe difference in the calculations of aſtronomers, even with reſpect to the diſtance of the ſun—that it is wiſeſt to confeſs our ignorance," namely, with regard to their diſtance.

To prove that we are not ignorant hereof, you ſay, "The knowledge of the ſun's diſtance depends on finding its parallax, or the angle that the ſemi-diameter of the earth appears under at the ſun, which angle is ſo very minute, that an error of but a ſingle ſecond, will give the diſtance very conſiderably greater or leſs than the true diſtance." It will: and therefore I doubt, whether the diſtance of any heavenly body can ever be known by this means.

"But Dr. Keil ſays, we are aſſured by various methods made uſe of to obſerve the ſun's parallax, that his diſtance from us is more than twenty-eight millions of miles." He may be aſſured: but I am not. "He

ſays

ſays farther, two eminent aſtronomers have ſince determined the ſun's diſtance to be about ſeventy-ſix millions of miles: now if the leaſt diſtance poſſible is abſolutely determined, how can it be wiſeſt to confeſs our ignorance?" If it be—but I doubt, it cannot be determined at all: at leaſt, not by the ſun's parallax: "ſeeing this is ſo very minute that an error of a ſingle ſecond will give the diſtance very conſiderably greater or leſs than the true."

R. 2. In p. 143, you tell us.——The whole paragraph runs thus. "It is now almoſt univerſally ſuppoſed, that the moon is juſt like the earth, having mountains and vallies, ſeas with iſlands, peninſulas and promontories, with a changeable atmoſphere, wherein vapours and exhalations riſe and fall. And hence it is generally inferred, that ſhe is inhabited like the earth, and by parity of reaſon, that all the other planets as well as the earth and moon, have their reſpective inhabitants." [I take this to be the very ſtrength of the cauſe. It was this conſideration chiefly, which induced me to think for many years, that all the planets were inhabited.] "But after all comes the celebrated Mr. Huygens, and brings ſtrong reaſons why the moon is not, and cannot be inhabited at all, or any ſecondary planet whatever. Then" (if the firſt ſuppoſition ſinks, on which all the reſt are built) "I doubt we ſhall never prove that the primary are. And ſo the whole hypotheſis, of innumerable ſuns and worlds moving round them, vaniſhes into air."

In order to prove that there are innumerable ſuns, you ſay, 1. "It is found by obſervations on the parallax of the earth's orbit, that a fixed ſtar is ten thouſand times farther from the ſun than we are."

I can build nothing on theſe obſervations, till parallaxes can be taken with greater certainty than they are at preſent. Therefore I ſtill want proof, that any one fixed ſtar is one thouſand times farther from the ſun than we are.

2. "They are fiery bodies." I ſuppoſe they are.

But

But this cannot be proved from their diſtance, till that diſtance itſelf is proved.

3. " It is demonſtrable, that Sirius is as big as the ſun."

Demonſtrate it who can.

4. " Seeing the fixed ſtars are not much leſs than the ſun, they are to be eſteemed ſo many ſuns."

Not much leſs! How is this proved? To argue from the diſtance, is to prove " ignotum per æque ignotum."

" You ſee, ſir, the hypotheſis of innumerable ſuns, is ſo far from vaniſhing into air, that it is almoſt altogether founded on demonſtration."

Indeed I do not ſee one tittle of demonſtration yet from the beginning to the end.

In order to prove that the planets are inhabited, you ſay, 1. " The earth is ſpherical, opaque, enlightened by the ſun, caſting a ſhadow oppoſite thereto, and revolving round it, in a time exactly proportioned to its diſtance. The other planets reſemble the earth in all theſe particulars. Therefore they likewiſe are inhabited." I cannot allow the conſequence.

2. " The earth has a regular ſucceſſion of day and night, ſummer and winter. So probably have all the planets. Therefore they are inhabited." I am not ſure of the antecedent. But however that be, I deny the conſequence.

3. " Jupiter and Saturn are much bigger than the earth." Does this prove that they are inhabited?

4. " The earth has a moon, Jupiter has four, Saturn five, each of them larger than ours. They eclipſe their reſpective planets, and are eclipſed by them."

All this does not prove that they are inhabited.

5. " Saturn's ring reflects the light of the ſun upon him."

I am

I am not ſure of that. And till the fact is aſcertained, no certain inference can be drawn from it.

6. "But is it probable God ſhould have created planets like our own, and furniſhed them with ſuch an amazing apparatus, and yet have placed no inhabitants therein?"

Of their apparatus I know nothing: however if all you aſſert be the probability of their being inhabited, I contend not.

7. "They who affirm, that God created thoſe great bodies, the fixed ſtars, only to give us a ſmall dim light, muſt have a very mean opinion of the Divine Wiſdom."

I do not affirm this, neither can I tell, for what other ends he created them: he that created them knows. But I have ſo high an opinion of the Divine Wiſdom, that I believe no child of man can fathom it. It is our wiſdom to be very wary how we pronounce concerning things which we have not ſeen.

R. 10. "Suppoſe ſome intelligent being in one of the planets, who were

Slaves to no ſect, who ſought no private road,
But look'd thro' nature up to nature's God:

viewed the earth from thence, they would argue, it muſt be inhabited, as we argue that the other planets are. But the ſuperſtitious would oppoſe this doctrine, and call it mere uncertain conjecture."

I ſee no argument in this: but perhaps I do not underſtand it. Are you applauding the ſuppoſed inhabitants of Venus, for not being ſlaves to the chriſtian ſect? Otherwiſe, what has ſuperſtition to do in the caſe? Why is this dragged in by the head and ſhoulders? If there be ſuperſtition here, it is on your ſide, who believe becauſe you will believe: who aſſent to what you have no evidence for, and maintain what you cannot prove. At preſent you are the volunteer in faith: you ſwallow what choaks my belief.

R. 11. "You quote Dr. Rogers,"—But I do not undertake to defend his hypotheſis, or any other. "Our beſt obſervators could never find the parallax of the ſun to be above eleven ſeconds." But I cannot depend on their obſervations: eſpecially when I find one of the chief of them, in computing the diſtance of the ſun, to ſtride from twenty-eight millions of miles, to ſeventy-ſix: near fifty millions of miles at once! After this let any impartial man judge what ſtreſs is to be laid on parallaxes!

"But Dr. Rogers ſuppoſes the parallax of the un to be five minutes, which others cannot find to be above eleven ſeconds. Why Doctor, if this be true" (namely, that the parallax which was lately but eleven ſeconds, is now increaſed to five minutes) "the earth has approximated thirty times nearer" (a little harmleſs tautology) "to the ſun." That is, if both the computation of Mr. Keil, and that of Dr. Rogers be true! But whoever ſuppoſes this? If the one be true, the other is undoubtedly falſe.

"To conclude. Since there is no arguing againſt facts, and ſince the ſun's parallax is found not to exceed eleven ſeconds, ought you not to give up that hypotheſis as abſurd and ridiculous?"

Yes, as ſoon as any of thoſe facts appear: till then I neither eſpouſe nor give it up. But I ſtill look upon it as extremely ingenious, and full as probable as any other.

Before I conclude, permit me, ſir, to give you one piece of advice. Be not ſo poſitive: eſpecially with regard to things which are neither eaſy nor neceſſary to be determined. I ground this advice on my own experience. When I was young I was ſure of every thing. In a few years, having been miſtaken a thouſand times, I was not half ſo ſure of moſt things as before. At preſent I am hardly ſure of any thing, but what God has revealed to man.

Upon the whole, an ingenious man may eaſily flouriſh on this head. How much more glorious it is for the great God to have created innumerable worlds, than this little globe only! But after all, I would aſk one plain queſtion. Suppoſe there are more worlds than there are ſands on the ſea-ſhore? Is not the uni-

verſe

verſe finite ſtill? It muſt be, unleſs it be God. And if it be finite, it can ſtill bear no proportion to him that is infinite: no more than this ball of earth does. How large ſo ever it be, ſtill compared to him it is as nothing, as the ſmall duſt of the balance. Do you aſk then what is this ſpot to the great God? Why, as much as millions of ſyſtems. Great and little have place, with regard to us: but before him they vaniſh away. Enlarge the bounds of creation as much as you pleaſe, ſtill it is but a drop to the Creator.

And ſtill the power of his Almighty hand,
Can form another world from every ſand!

Yet were this done, there would be no more proportion between the world and its Creator, than there is now!

It will eaſily be obſerved that I do not deny, but only doubt of the preſent ſyſtem of aſtronomy. But the ingenious Mr. Kennedy goes much farther in his aſtronomical chronology. I beg leave to preſent the impartial ſearchers after truth, with a ſhort extract from it.

"Although many perſons of great abilities have thought ſacred chronology worthy their moſt diligent reſearches, yet they have all failed in the main point. They have taken it for granted, that the ſcriptural computations are quite unaſtronomical. The title of "The World's Chronology," has been fixed to very different collections of years, without looking for any aſtronomical æra, to ſuppport the title. This is the firſt attempt of that kind which has been made.

"I have lately proved the fundamental propoſition of the following ſcheme, namely, that Moſes fixes the poſition of the ſun and moon, with regard to each other at the creation. And this revealed poſition of the ſun and moon, with reſpect to each other at the creation, I call the ſcriptural, aſtronomical æra.

"By means of this æra we may keep even pace with the two great luminaries, from the firſt year of the world

world till now. And till now my concluſions are confirmed, by the joint atteſtations of the ſun and moon, the two faithful witneſſes in heaven.

" By theſe it is fully proved, that time commenced at our autumnal equinox, at the fourth day of the creation, at the full-moon, or the fifteenth day of the firſt month of the firſt lunar year.

" From the autumnal equinox at the creation to the ſame in 1761, have elapſed 5768 years. Indeed Capellus ſuppoſes time to commence two years, Archbiſhop Uſher four years later. But could the error of a ſingle year be diſcovered in the ſeries I have collected, all would fall to the ground.

" Touching the common aſtronomy, I obſerve, 1. Aſtronomers ſtill divide the ecliptic into 360 degrees. But how unnaturally ? Three hundred and ſixty degrees, and near one fourth, are undeniable more correſpondent to the ſun's annual motion. And upon this diviſion we can make a truer calculation, than can be made upon any other.

" 2. The inequality of ſolar tropical years, and the inequality of equations of natural days, are eſtabliſhed doctrines. But whoever computes the times of equinoxes and ſolſtices, and ſubmits his calculations to the teſt of the lateſt and beſt obſervations, will find no room for any equations at all.

" 3. Aſtronomers unanimouſly maintain, that at the end of nineteen luniſolar years, the mean new moons, and the mean full moons happen, about an hour and a half ſooner than they did at the beginning of the cycle. On the contrary, I undertake to evince, that the very reverſe of this is true. I allow, that at the end of nineteen luniſolar years, the moon departs from the ſun : but it departs from it, not by a retroceſſion weſtward, but by a progreſſion eaſtward. That is, the mean new moons and the mean full moons fall out, not an hour and a half ſooner, but almoſt two hours later. Therefore the doctrine of lunar anticipations has no foundation in nature.

" 4. Although

" 4. Although the quantity of a ſolar tropical year is a concluſion in aſtronomy, yet ſuch an unhappy fatality has attended this reſearch, for almoſt two thouſand years paſt, that whoever examines the vaſt variety of opinions, muſt ſee nothing has yet been determined with certainty. So that inſtead of a preciſe and eſtabliſhed definition, he finds little more than this general account, that the quantity of the natural year has been long and much ſought after, but with ſmall ſucceſs: ſo that it ſeems at this day to remain among the yet undiſcovered ſecrets of nature.

" Indeed to know this with all exactneſs, one would think no more is needful than to examine the tables of obſervations. Let us then examine that made by Tycho Brache, in Queen Elizabeth's time, and that by Doctor Bradley a hundred and ſeventy years after. But in Tycho's table of twelve terminations, ſeven of them differ a minute from the other five. And this difference perplexes the concluſion, and leaves it in a ſtate of uncertainty. Proceed we then to Dr. Bradley's tables. But theſe leave a latitude of twenty-one minutes. Thus we ſee how imperfect the knowledge even of the ſolar tropical year ſtill is, and that no true judgment can be formed concerning it, either from obſervation or tabular calculation.

" 5. It requires no ſmall ſkill, even to determine the diſtances of the ſun's four ſtations, at the vernal and autumnal equinox, and the ſummer and winter ſolſtice. Nay, it is a queſtion whether this determination likewiſe muſt not ſtill be reckoned among the ſecrets of nature.

" And if we ſhould correct the tables of theſe by Dr. Keil's Rule, yet this very correction leaves us four different meaſures according to the majority of Tycho Brache's corrections, according to Sir Iſaac Newton's, Dr. Halley's, and Dr. Bradley's corrections. So that ſtill we come to no certainty, even as to the ſolar ſtations. We are at a ſtand, like a traveller, who arriving at a place where four ways meet, is at a full ſtop, for want of a clear diſtinction, which of them to take.

" 6. The

" 6. The greateſt aſtronomers are not agreed, even as to the length of a natural day.

" Mr. Ferguſon obſerves,

" The fixed ſtars appear to go round the earth in twenty-three hours, fifty-ſix minutes and four ſeconds, and the ſun in twenty-four hours. Therefore in three hundred and ſixty-five days, meaſured by the returns of the ſun to the meridian, there are three hundred and ſixty-ſix days as meaſured by the ſtars returning to it. The former are called ſolar days, the latter ſidereal. But whoever will compare this with the determinations of Dr. Keil, will find them flatly contradictory to each other. And the farther he examines the moſt celebrated writings, the more deeply he will be convinced, that neither the preciſe length of a ſidereal day, nor the complement of the ſolar, has yet been determined with certainty."

Whoever deſires to ſee theſe propoſitions proved at large may have recourſe to the book itſelf. But if theſe things are ſo, what becomes of the whole fabric of even Newtonian aſtronomy? How can I depend on the calculations of thoſe concerning the motions of the heavens, who know ſo little about the earth? What inſtructions can they give me concerning other ſyſtems, who are ſo unſkilled with regard to our own? Why does not ſome eminent aſtronomer undertake this daring man, who ſo violently attacks the very foundation of their building? For if his remarks are juſt, ſenſible men will be inclined to think, that after all the parade of mathematical demonſtration, there is little more certainty in aſtronomy itſelf, that even in judicial aſtrology!

And how juſt are the great Mr. Boyle's remarks, upon the whole of Natural Philoſophy? " The moſt, ſays he, even of modern virtuoſi, fancy more certainty in their phyſical theories than a critical examiner will find. I will touch only on two ſubjects, which we commonly think are, and which ſurely ought to be, moſt thoroughly underſtood: I mean, the nature of the body in general, and the nature of ſenſation. As to the firſt, ſince we turn ourſelves no way, but we are environed

roned by corporeal ſubſtances, one would think, an object that ſo many ways affects our ſenſes, ſhould be perfectly known to us. And yet the notion of the body in general, or what it is that diſcriminates bodies from other ſubſtances, is not by any means agreed even among the modern philoſophers. And indeed, no account of it, which has yet been given, will extricate us out of the difficulties of that no leſs perplexed than famous diſpute, "Of the Compoſition of Bodies." But the difficulties attending this, will, till they are removed, ſpread a thick night over the notion of bodies in general. For either a corporeal ſubſtance is diviſible into extended parts, and each of theſe diviſible into other parts ſmaller and ſmaller, ad infinitum, or this diviſion muſt ſtop ſomewhere. But there are inconveniences, not to ſay abſurdities urged againſt either of theſe ſuppoſitions. The objections on both ſides are ſo ſtrong that the moſt ſenſible and candid men, after having tired themſelves and their readers with ſtriving to ſolve them, have at length owned them to be inſoluble.

"But though we do not underſtand the nature of bodies in general, muſt we not perfectly underſtand what paſſes within ourſelves, in reference to the particular bodies we daily ſee, and hear, and ſmell, and taſte, and touch? Theſe we know by our ſenſes: but how little do we know of the manner wherein our ſenſes inform us of any thing? Senſation we allow is not performed by the organ, but by the mind perceiving the motion produced in the organ. Aſk then a philoſopher how the ſoul comes to be wrought on, and that in ſuch various manners, by thoſe external bodies, which are the objects of our ſenſes? He will tell you, that by the impreſſion on the organs, they variouſly move the nervous fibres, wherewith thoſe parts are endowed, by which the motion is propagated to the brain: where theſe motions being perceived by the ſoul, become ſenſations, through the intimate union of the ſoul with the body. But give me leave to take notice that this union of an incorporeal with a corporeal ſubſtance, is a thing ſo difficult to comprehend, that the profoundeſt ſecrets of theology, not to ſay the incarnation itſelf, are not more abſtruſe than this. For how can we conceive

ceive that a ſubſtance purely immaterial, ſhould be united without any medium (and in this caſe there can be none) with a body that cannot poſſibly lay hold on it, and which it can pervade and fly away from at pleaſure? And it is almoſt as difficult to conceive, how any part of the body, without excepting the animal ſpirits of the brain (for theſe are as truly corporeal as the other parts) can make impreſſion on a ſubſtance perfectly incorporeal, and which is not affected by the motions of any parts but the nerves. Nor is it a ſmall difficulty to conceive how a finite ſpirit, can either move, or (which is much the ſame thing) regulate and determine the motion of the body.

"And ſuppoſe the ſoul in the brain does perceive the different motions communicated to the ſenſes, yet this, though it may give ſome account of ſenſation in general, does not give us any ſatisfactory reaſons of particular ſenſations. For if I demand, for inſtance, when I look on a bell that is ringing, ſuch a motion, in the brain produces in the mind the perception of ſeeing and not hearing, and another motion coming from the ſame bell at the ſame time, produces in the mind, the perception of hearing, not ſeeing: what can be anſwered, but that ſuch is the good pleaſure of the Author of Nature? And if we aſk about the differing objects of any one ſenſe, as, why the light reflected from ſnow, produces a ſenſation of whiteneſs rather than redneſs? Why Caſtor produces a ſtink, and not a perfume? Why ſweet things generally pleaſe, and bitter diſguſt us? Nay, why a little of ſome objects (ſuppoſe fire) will give pleaſure, a little more of them give pain? To theſe and a thouſand other queſtions of the ſame kind, it can only be anſwered, ſuch is the nature of man. So plain is it, that we are yet to ſeek both for the definition of a corporeal ſubſtance, and for a ſatisfactory account of the manner of our own ſenſations. Yet without the true notion of a body, we cannot underſtand the object of phyſics in general: and without knowing the nature of the ſenſation, we are ignorant of that, from which we derive almoſt all that we know of any body in particular.

"And as our philoſophical knowledge is not very deep, not reaching with any certainty to the bottom of the

the moſt obvious things, nor penetrating to their inmoſt natūre: ſo it is not very wide, not being able to give us with any clearneſs or particularity, an account either of the celeſtial parts of the world, or of the deeply ſubterraneous parts of which the ſuperficial part is but a ſmall, not to ſay contemptible portion. As to the very globe we inhabit, (not to mention how many plants and minerals we are wholly ignorant of, and how many others we are but ſlenderly acquainted with) the objects about which our inquiries and experiments are converſant all belong to the ſuperficial parts of the globe, of which the earth known to us is but the cruſt. But what the internal part of it is, we no more know, than what is the ſubſtance of the remoteſt ſtars. Even among the moderns ſome think the internal part of it, is pure elementary earth. Others imagine it to be fire, the receptacle of natural or helliſh flames. Others will have the earth to be a ſolid magnet; while others believe it was once a fixed ſtar: and that though it is now degenerated into a planet, yet its internal parts are of the ſame nature as before: the change proceeding only from thick ſpots that cover it, (like thoſe frequently obſerved upon the ſun) by the condenſation whereof the firm earth, which we inhabit, was formed. And it is as difficult to demonſtrate the falſehood, as the truth, of each of theſe jarring opinions. For whereas it is at leaſt three thouſand five hundred miles to the centre of the earth, it does not appear, that men have been able to penetrate towards it either by land or by ſea, above one, or two miles at the moſt, and that not in above three or four places. So that as yet we have not penetrated any thing deep upon the huſk, without at all reaching the kernel of the globe. And what is this globe, of which itſelf we know ſo little, to thoſe vaſt globes of which we know much leſs? For though the former aſtronomers give us their diſtances and magnitudes as exactly as if they had meaſured them, yet the latter mathematicians give us reaſon to doubt of what thoſe have delivered. For ſince we can obſerve no parallax in the fixed ſtars, (nor perhaps in the higheſt planets) we muſt ſtill be to ſeek for a method to meaſure the diſtance of thoſe bodies. And not only the Copernicans make it many hundred thouſand

ſand miles greater than the Ptolemeans, but Ricciolus makes it vaſtly greater than the Copernicans themſelves. Nor can we wonder at theſe huge diſcrepances (though ſome amount to many millions of miles) when we conſider that aſtronomers do not meaſure the diſtance of the fixed ſtars, by their inſtruments, but each accommodates the diſtance of them to his peculiar hypotheſis. From this uncertainty of the diſtance of the fixed ſtars, it is eaſily inferred, that we are not ſure of their bulk: no, not even in reference to one another: ſince it is doubtful whether the different ſizes they appear to be of, proceed from an inequality of bulk, or only from an inequality of diſtance. But beſides theſe, there are divers things relating to the ſtars, ſo remote from our knowledge, that they are not even inquired into: ſuch as theſe, Why the number of the ſtars is neither greater nor leſs than it is? Why ſo many of them are ſo placed, as not to be viſible to the naked eye? Why of the viſible ones, ſo many are in one part of the ſky, and ſo few in others? Why they are not placed in ſome order, but ſcattered over the ſky, as if it were by chance? Many queſtions might be added, as concerning the ſtars, ſo concerning the interſtellar parts: as whether they are empty, ſave where they are pervaded by light, or filled with ethereal matter? So that our knowledge is much ſhort of what is generally thought. For the earth being but a point compared to the orb of the ſun: which orb itſelf is but a point in reſpect of the firmament: of how little extent muſt our knowledge be which leaves us totally ignornant of ſo many things touching the vaſt bodies which are above us, and penetrates ſo little a way into the earth beneath us, that it ſeems confined to but a ſmall ſhare of a ſuperficial part of a phyſical point."

Perhaps it will be acceptable to calm, diſpaſſionate men, if I add another extract from a very ſenſible writer, containing a few ſhort obſervations, on the whole preſent ſyſtem of philoſophy.

1. The firſt axiom in the preſent philoſophy is, that all "matter is indifferent to motion or reſt." But do we not

not here ſtumble at the threſhold? laying as a fundamental truth, what is manifeſtly falſe? For motion and reſt are ſuch oppoſites, that it implies a contradiction to ſuppoſe an equal diſpoſition to either, inherent in the ſame body. The one is a poſitive, which neceſſarily implies power, the other a mere negative, which implies no power in any direction.

2. Matter containing in itſelf no power of any kind, can give no reſiſtance to any impreſſion upon it: neither can it of itſelf continue to exert the effects of that impreſſion. Therefore the ſecond axiom, or rather the phenomena, from which it is deduced, muſt ariſe, not from matter in itſelf, but from the relation which all matter bears to the univerſal ſyſtem of nature.

3. The third axiom, concerning re-action is as exceptionable as the two former. For it may eaſily be ſhewn, that the re-action of matter depends entirely on gravity. If gravity were ſubtracted, there is no proof or reaſon to ſuppoſe, that bodies would exert either reſiſtance or re-action. All theſe axioms therefore, inſtead of being abſolute laws, are mere phenomena depending on other cauſes, which cauſes it is incumbent upon the philoſopher to look for.

4. The projectile power never can balance that of gravitation, ſo as to maintain the motion of the planets. It can never recover its force when it is reſiſted, whereas gravity can. Therefore the conſtant bending of its direction, which muſt be equal to a conſtant proportionable reſiſtance, muſt uniformly and perpetually weaken its power, and ſtrengthen that of gravitation; ſo that the direction of motion muſt neceſſarily ſink more and more, and at laſt fall wholly into the direction of gravitation. It follows that no power acting upon an orb which gravitates towards its centre of motion, can poſſibly maintain its projectile motion, in the direction of a circle.

5. Even on ſuppoſition that projection and gravitation equally retained their propenſity to motion though

though reſiſted, yet thoſe powers could not move the planets in eclipſes, becauſe in the ſame proportion as the one prevailed over the other, in the ſame proportion it muſt alter the tendency of motion towards its own direction. And none can explain how, when a quantity of motion and alſo of inclination is gained by gravitation over projection, the orb will, while theſe remain unchanged, leave at any point the direction of the moving power that prevails, and recede into the direction of the weaker power, or é contra.

6. Again. From the proportions of the forces required between gravitation and projection, in order to move the orbs in circles, it is evident that theſe two powers cannot be the cauſe of their motions. For by comparing the forces of theſe it appears, that the force of gravitation is not ſuch in proportion to that of projection, as to bend the direction of the projected body ſenſibly from the right line.

7. The motion of the moon along with the earth, cannot be owing to her gravitating towards it, nor to a projection impreſſed upon her, in common with the earth: becauſe ſhe has a projection of her own round the earth. And ſhe cannot be ſo projected as to move in two different orbits at one and the ſame time, by the vis inertiæ continuing one projectile motion round the ſun, and another round the earth. Therefore the motion of this, and by a parity of reaſon, that of all the ſecondary planets, muſt be guided every moment either by mechaniſm or by a ſpiritual power.

Indeed Sir Iſaac thought theſe powers might ariſe from a ſubtle, ethereal medium, diffuſed through the whole univerſe: but this is only retiring a ſtep farther in the dark. For it comes to one, whether the cauſe of attraction be aſſigned to groſſer bodies themſelves, or to the impulſe of a medium that penetrates them. If the powers of that ſuppoſed medium are unmechanical, they muſt be ſpiritual. And ſeeing the medium is only ſuppoſed, it is more natural to aſſign theſe unmechanical powers, to bodies which we know diſpoſed

poſed to theſe motions, than to ſuppoſed bodies, which we know nothing of.

Farther. If Sir Iſaac ſuppoſes ſuch a medium for maintaining attraction, gravitation, and elaſticity, how came he not to ſuppoſe that the ſame is concerned, in ſupporting his axioms or laws of motion? For the knot does not lie in gravitation or attraction, or any particular kind of motion, but in finding powers to produce and maintain motion in general. If theſe are mechanical, it is eaſy to ſuppoſe, though we ſhould never be able to explain in what manner that the contriver has adjuſted the mechaniſm to produce all the motion obſervable in the creatures. But if they are unmechanical laws, properties, or whatever we may call them, there is no occaſion for ſuppoſing any cauſe of gravitation, or for taking it amiſs to have it called an occult quality, unknown virtue, charm, law, or any word we have no meaning to.

8. This unmechanical philoſophy has a bad influence in obſtructing our advancement in the knowledge of nature. For how can inquiries into the powers of nature be carried on to any degree of perfection, under the direction of a ſyſtem which muffles our eyes with unmechanical laws of matter, ſuppoſe the baſis of mechaniſm, inſtead of examining whether theſe themſelves are not the production of mechaniſm? Such is the indifference of matter to continue itſelf either in reſt or motion: re-action equal to action: the reſiſtance of action to a change of ſtate: gravitation, attraction, repulſion, elaſticity: preſſure of fluids in all directions: a fluid with no coheſion of parts, moving in diverging lines; whoſe parts are poſſeſſed of different degrees of attractability by other bodies, contrary to that law which makes gravitation ſimply as the quantities of matter: a fluid poſſeſſed of alternate fits of attraction and repulſion! How weak is it, to make theſe the baſis of mechaniſm, rather than the reſult of it?

9. Let us now examine theſe matters more cloſely. In the preſent philoſophy, ſpace is always conſidered in the firſt place; becauſe without admitting ſpace

void of matter, the whole ſyſtem falls to the ground.

This ſame infinite ſpace is the moſt wonderful thing within the whole range of being. It is neither God, nor his creature, and yet is inſeparable from the being either of God, or of any thing he can create. It is infinite both in its extenſion and its duration. It is immoveable and indiviſible. If a complete definition of it were put into a lady's pocket-book, ſhe would gueſs it to be an enigma for nothing: and would be aſtoniſhed to hear, that it is the quinteſſence of a moſt metaphyſical and moſt ſubtle argument maintained by a moſt celebrated divine and philoſopher.

The only poſitive idea applied to ſpace is extenſion. But we can apply no idea to any ſubject, which the ſubject itſelf does not impreſs. Matter forces upon our ſenſes the idea of its extenſion. But how can we inveſt with this, a ſubſtance which never excited any idea in us, and conſequently has no exiſtence to us? Space is only one of the ideas excited by matter, and by the mind abſtracted from its ſubject, juſt as we can image a colour to ourſelves, without connecting any particular ſubject with it. A little more of the ſame metaphyſics, which can prove that nothing is extended, will prove that ſpace is purple. But why ſhould I ſay purple? Space is of all colours, if light is reflected by a vacuum. It is an ingenious contrivance to render nothing a ſubject of conception, by dreſſing it in a ſuit of clothes borrowed from ſomething.

To illuſtrate the doctrine of ſpace, a common experiment ſhews, that by an image formed in the air, at a certain diſtance between a concave glaſs and any perſon looking into it, extenſion becomes an object of ſenſe, where there is neither ſolidity nor any ſenſible reſiſtance. But this does not prove that an image is formed in empty ſpace, or where there is no matter: it rather proves that theſe ſpaces which they call empty, are full of matter. For as the ſenſes can be affected only by matter, they infallibly determine where matter is. So that we are as ſure there is matter where we ſee any thing, though we cannot feel it, as that it is there, where we feel, though we cannot ſee it.

10. Let

10. Let us now more attentively conſider the firſt ſuppoſed law of motion, matter is indifferent to continue in motion or in reſt.

Reſt and motion are the two greateſt oppoſites in nature, as oppoſite as matter and nothing. The mind therefore cannot be ſtruck with a more palpable contradiction, by affirming that a body is equally diſpoſed to hardneſs and ſoftneſs at the ſame time, than by ſaying it is equally diſpoſed to reſt and motion.

Motion is a poſitive thing, which implies action, power, or force, wherever it acts. Reſt is a mere negative, a ſtate wherein body is diveſted of all theſe. It exerts no power; it acts or preſſes, neither backwards nor forwards, neither up nor down. Now the ſame body cannot be indifferent to the exerting of power and to the exerting of none at the ſame time.

Again. It is impoſſible that reſt and motion can be equally indifferent to matter. When matter was created, ſhould we ſuppoſe the Creator to ſay, "Let it be," without determining in which of theſe ſtates it ſhould commence being; yet it is impoſſible it could begin to be, both moving and reſting. It could aſſume only one of theſe conditions, and muſt have remained therein for ever, unleſs ſome farther divine energy had given it a new determination. Now in which ever of theſe matter began to exiſt, that muſt be called its natural ſtate. And every alteration of that ſtate muſt be the effect of ſome power ſuperinduced upon it, which muſt ceaſe when the cauſe ceaſes.

Again. Matter may exiſt in reſt: but no living matter. All life in nature, whether, mineral, vegetable, or animal, depends upon motion and activity. Therefore motion ſeems to be not the natural ſtate of matter, but ſuperadded thereto, and conſtantly ſupported, in order to conſtitute life, variety, and mutability. Now all know, material motion proceeds upon, and is regulated by mechanical laws. And does not motion uniformly conducted by the laws of mechaniſm, imply a conſtant mechanical cauſe? This mechanical ſyſtem is traceable in moſt caſes, even in the moſt ſubtle and elaborate works of nature, ſuch as plants and ani-

mals. And may not the ſame heavens which influence every thing on earth, rule the motions of the earth itſelf; and impreſs all matter with theſe general tendencies, which are the baſis of all human mechanics?

11. Proceed we to what is called the ſecond law of motion.

We can have no idea of power, but that it is matter in motion, or endeavouring to act. We cannot connect the idea of power with matter at reſt, unleſs that reſt be the effect of power fixing it in its place, which we may term mechanical power. This reſt, being an effect of power, will exert a reſiſtance to motion, when it is preſſed upon. But otherwiſe, matter can have no ſuch power in itſelf, can exert none; becauſe power conſiſts in motion, or a niſus to it. Therefore matter reſting unmechanically can have no niſus of any kind. An unmechanical niſus in matter to reſt, is in other words an active power exerted by it to do nothing.

The ſtates then in motion or reſt being the reſult of abſolute paſſiveneſs in matter, and the effect of no poſitive niſus, an unmechanical matter can exert no reſiſtance to change the ſtate: and of conſequence an atom would have as much power to move a planet as a planet to move an atom.

An action or tendency to action is plainly implied in a niſus to any ſtate. And as a niſus to paſſiveneſs is a contradiction in terms, it follows, that the properties of power and motion, cannot be conſidered in matter taken abſtractedly, but as compoſed into a ſyſtem. Therefore, though it muſt be allowed, that the changes of ſtate in matter are proportioned to the powers that produce them, yet it is impoſſible to conceive, that the power ſhall continue in the body acted upon, after the exterior power ceaſes to act upon it.

12. The third ſuppoſed law of motion is this, when matter is put into motion, it communicates as much reſiſtance towards ſtopping the motion of the body that moves it, as it receives motion from it.

Philoſopher

Philoſophers never had it in their power to make the experiments on which this law is grounded, upon any bodies but ſuch as were under the influence of gravitation. And if this axiom can be proved to depend upon gravitation, it muſt ceaſe to be an axiom, as being only an accident depending upon another acknowledged cauſe.

Reſiſtance or re-action muſt be produced wherever matter in motion encounters matter moving or tending to move in an oppoſite or a different direction. Now all bodies tend or gravitate toward the earth. Therefore this tendency muſt re-act or reſiſt according to its quantity, every power applied to move a gravitating body in any other direction.

We have no way to eſtimate the quantity of matter contained in any bodies, but the quantity of their gravitation. Hence we muſt neceſſarily infer, that the law of re-action, is not according to the quantity of matter in particular detached parcels thereof, but according to the degree of their gravitation. For were the gravity of a body but the half of what it is now, that body would re-act but half as much as it does; and of courſe, were all its gravitation to ceaſe, it would not re-act at all.

Again. It is ſuppoſed, gravitation is twenty-three times greater on the ſurface of the ſun than on the ſurface of the earth. Hence a body which weighs one pound here, would there weigh three and twenty. Conſequently without any addition of matter, it would re-act twenty-three times more than it does here. Therefore this re-action, ſuppoſed an abſolute law of matter, is only a circumſtance depending on the relative law of gravitation.

13. Come we now to the doctrine of centripetal and centrifugal forces.

In another age it will be matter of univerſal wonder, that one of the moſt profound mathematicians in the world ſhould aſſume two powers for circulating the planets, and even circulate the quantities of matter therein, from the proportions wherein they muſt act

in

in producing and maintaining the circuits of the moving ſtars: while it is demonſtrable to common ſenſe, from the admitted nature of theſe two powers, that it is abſolutely impoſſible they can ſupport one ſingle rotation of an orb.

Gravitation is allowed by all to be a conſtant power in bodies, which cannot be altered but by change of diſtance. It cannot be ſuſpended; for though its effect may be reſiſted, yet its tendency thereto is invariable. It is therefore a proper undeſtroyable power, uninterruptedly acting in and upon bodies.

The laws aſſigned to projection are juſt the reverſe. When any proportion of the quantity of projectile motion is deſtroyed, either by direct oppoſition, or by change of its direction, it exerts no niſus to recover its firſt quantity of motion. Conſequently as long as any power, ſuch as that of gravitation, is bending the direction of projection, it is a continued reſiſtance of the power of projection, which is continually diminiſhed thereby. And as it has no tendency to recover this, the ſmalleſt continued reſiſtance will at laſt quite exhauſt its power, though originally ever ſo great. Thus every projectile on the earth, however great the projecting force may be at ſetting out, is continually retarded till it reſts in the direction of a parabolic curve.

Sir Iſaac ſeems not to have reflected on this circumſtance of gravitation and projection, that the one retains its whole tendency to motion, whether it be retarded or ſtopped, while the other always loſes as much power as it meets with oppoſition. Neither in balancing theſe powers, does he ſeem to have reflected on that obvious truth, that every alteration in the direction of a moving projectile, deſtroys ſo much of its motion, which cannot be repaired, but by a continued action of the firſt moving cauſe.

Philoſophers illuſtrate the joint effect of centripetal and centrifugal force, in making bodies mo in a circle, by the experiment of caſting round a weight, ſuſpended by a ſtring in one's hand. But this illuſtration contains a palpable deception. For the power of the ſtring reſtraining the body from flying off in a ſtrait line

ſtne, bears no analogy to a power actually drawing a moving body towards its centre of motion. The ſtring reſiſts its flying off, but has not the leaſt tendency to draw it nearer. And whatever is the cauſe of the revolution of the planets, it muſt be ſome cauſe which ſimply reſiſts their flying off into eccentric motions. It cannot in the nature of things be one, which is uniformly drawing them into their centre of motion.

But ſuppoſe both gravitation and projection had the ſame property, of ſtill retaining their original tendency to their reſpective motions, however they were retarded: ſtill it is impoſſible that theſe two powers, acting by immutable laws, can move an orb any otherwiſe than in a circle: whereas all the planets are allowed by philoſophers themſelves to move in ellipſes.

Theſe powers moving an orb in the figure of an ellipſis, muſt no leſs than four times vary the proportion of their ſeveral impulſes, during every complete revolution. The power of gravitation is uniformly gaining on that of projection, from the higher point of the ellipſis to the lower. Now (not to aſk how the projectile force recovers itſelf, but ſuppoſing it had this property) I aſk, by what law does gravitation remit the ſtrength it has gained, in bringing the orb from the higher point to the lower, and at that point allow projection to recover the force it had loſt, in order to carry it back to the higher point? In like manner ſeeing projection has been gaining on gravitation, all the way to that point, how comes it all at once to loſe its ſuperior force there? And how comes gravitation immediately to preponderate, in order to bring the orb to the lower point again?

It cannot be ſaid, that the increaſed velocity, which brings a planet to the lower, contributes to carry it back to the higher point. For that increaſed velocity was not the effect of projection but of gravitation. Therefore the orb can never get outward again, unleſs at that point, gravitation all at once weakens its pull of the planet inwards.

There is one circumſtance more, which mathematicians ought to conſider well: namely, that no figure (circle or ellipſis) can be deſcribed by gravitation and projection

projection round the centre of gravity, where the centre of gravity ſhall not be found in the centre of the figure. But this is contrary to all aſtronomical obſervation upon the motion of the planets, which determines their centre of gravity to be always in one of the foci of their elliptical orbits.

Yet farther. In order to move any body in a circle, the moving powers muſt be equal, or nearly ſo. Now the proportion of the moving powers upon one body to each other, can only be determined by the velocity of the reſpective motions. Indeed the quantity of motion in different bodies muſt be determined by the quantity of matter moving and velocities taken together. But in one and the ſame body it may be determined ſolely by the velocity of its motions.

Equal powers then can only be determined by the equal quantities of motion they produce. But as to the powers of gravitation and projection, the proportion between them, as aſcertained by the ableſt mathematicians, is ſo far from being equal, that the immenſe diſparity between them, can ſcarce be reduced to a calculation. Therefore it is utterly impoſſible that theſe two powers ſhould produce the revolution of the earth.

If the ſun and earth were as near each other as the earth and the moon are, and were left to the power of their mutual attraction, they would move toward each other with the ſame velocity as it is ſuppoſed the earth and moon do, which I think is about ſixteen feet in a minute: except ſo far as the proportion of matter in the earth to that in the ſun, differs from that of the earth to the moon. If then the earth at that diſtance from the ſun, would gravitate toward him with the velocity of ſixteen feet in a minute, and if the decreaſe of gravitation, be inverſely as the ſquares of the diſtances, (that is, at double diſtances four times leſs) then the earth being immenſely farther from the ſun than the moon is from the earth, the velocity with which the earth at her preſent diſtance from the ſun would move towards him, if left to the power of attraction, muſt be immenſely leſs than ſixteen feet in a minute. But what is the force which moves the earth ſixteen feet or a thouſand, to the force of that projection, which is

ſuppoſed

ſuppoſed to move it at the rate of near a thouſand miles in a minute?

In ſhort, if the power of gravitation draws the earth toward its centre of gravity, with the force of ſixteen feet, or ſixteen hundred in a minute, while the powers of projection impreſſes it with the force of almoſt a thouſand miles in the ſame time, it is impoſſible for mathematics to demonſtrate that any orb hurried off by ſuch a projection, can ever be recalled from its eccentric motion, by ſuch an inconceivably ſmall and diſproportionate reſiſtance: eſpecially as the power of gravitation, ſmall as it is, muſt be growing ſmaller every moment. Nor can the mathematical properties of an ellipſis, or any figure, ever prove the gravitation, which is continually waſting and ſpinning out into a cobweb thread, will at any point recover a ſuperiority to the projectile force, and grow at laſt a cable, maſſy and powerful enough to bring home the wandering ſtar again.

14. I would add ſome thoughts on the motion of the ſatellites. It is no wonder that notwithſtanding all the arguments for the motion of the earth, yet the greateſt part of aſtronomers have not pronounced it abſolutely certain, but only probable in a high degree. Among the perplexities which attend this highly probable ſyſtem, the doctrine of abſolute motion is not the ſmalleſt. It is certain all the phenomena of relative motion, are the very ſame as if the earth were at reſt. And it is not eaſy to conceive how this can poſſibly be, on the ſuppoſition of the earth's motion.

The phenomena of bodies moving in the ſame direction with the abſolute motion of the earth may be comprehended. That motion of bodies croſs the abſolute motion of the earth is alſo intelligible. But it is no eaſy matter to ſatisfy one's ſelf, about the phenomena of bodies moving weſtward, or in an oppoſite direction to that of abſolute motion. If we ſhould ſuppoſe that a ball fired pointed blank weſt, does not really move weſtward, but it is only reſiſted by the exploſion from moving ſo faſt eaſt as the earth goes in her

abſolute courſe; may it not be aſked, what is it, that keeps the ball ſuſpended, while the earth proceeds in her abſolute motion? For the reſiſtance given to the progreſſive motion of the ball, can be no reſiſtance to its following the courſe of its gravity: as we have no example to explain how reſiſtance applied horizontally will prevent a body's falling to the ground in the ſame time as if it was not ſo reſiſted. If the ball's abſolute motion is only the force of its vis inertiæ derived from the earth's motion, and its apparent motion in a contrary direction is only from another vis inertiæ, derived from the exploſion: what poſſible conception can be framed of the two oppoſite vis inertiæs, acting ſo as to prevent a body for ſome time from purſuing the courſe of its gravity?

On the other hand, if the motion weſtward is real, it ſeems to imply a plain contradiction. For no body can really move eaſtward and weſtward at one and the ſame time.

But though the doctrine of projectiles could be reconciled with the motion of the earth, yet what ſhall we ſay of ſelf-moving bodies? That abſolute motion which all bodies are ſuppoſed to partake of, is not alledged to be maintained in them, after they are ſeparated from the earth, by any other means than their vis inertiæ, or their retaining the quantity of motion once impreſſed upon them. Now no body can move in a direction oppoſite to its vis inertiæ, till that is overcome. How is it conceivable then, that birds, for example, after they are ſeparated from the earth, where they acquired their abſolute motion, ſhould retain it all? Certainly every reluctation of their's in an oppoſite direction, while on the wing, muſt deſtroy part of their abſolute motion, as they cannot then have any freſh abſolute motion communicated to them. This ſhould imply a great change in the phenomena, with regard to the motion of ſelf-moving bodies. But in fact all the phenomena are the ſame, as if the earth were at reſt. In ſhort, the motion which bodies have in common with the earth, is ſomething which no reaction has any effect on. Therefore it does not, cannot depend upon the axioms of the preſent philoſophy.

When

When we come to apply the theory of abſolute motion to the ſecondary planets, in whatever light we conſider it, it becomes a matter utterly inconceivable, nay, impoſſible. In the firſt place, we know of no abſolute motion, communicated from greater to ſmaller bodies, but where they are ſo intimately connected, that gravitation at laſt, yea ſoon deſtroys all their projectile motion. But ſuch is the diſtance of the moon from the earth, and ſo remote is their connection, that her gravitation has never gained any thing upon her projectile motion.

Again. The moon, ſuppoſe her preſent diſtance from the earth to be her original one, could never by means of the weak connection of gravitation, correſpond with their projection of the earth. Suppoſe the moon at her preſent diſtance, and behind the earth, juſt in the courſe of the earth's projection: in this ſituation, ſuppoſe the moon advances towards the earth, at the rate of ſixteen feet in a minute, while the earth projected away from the moon near a thouſand miles in the ſame time: can any one ſuppoſe, that this imperceptible motion of the moon toward the earth, would draw the moon with the force of the earth's abſolute motion? This ſuppoſition is attended with the ſame manifeſt impoſſibilities, in whatever part of her circle the moon is conſidered, at the moment of projection. Suppoſe her in her firſt quadrature: then the gravitation between them and the projection of the earth lying nearly in the ſame direction, nothing could prevent their colliſion in a few hours: and till they had met, their mutual gravitation could have no effect in communicating the abſolute motion of the earth to the moon. Yet ſuppoſing that the projection of the moon round the earth, commenced at the ſame inſtant with the projection of the earth, does not help: for as it is not that projection which gives the moon her abſolute motion, the whole impoſſibility remains, yea, and is renewed every month in every ſuppoſable circumſtance. For it is as impoſſible her abſolute motion can be maintained by ſuch means, as that it ſhould commence by them.

It is no leſs impoſſible, that the moon's abſolute motion can be owing to a projection given to herſelf, than that it ſhould be owing to her gravitation toward the earth: for this plain reaſon; becauſe ſhe has a projectile motion quite different from this, namely round the earth. For nothing is more impoſſible, than for a body to move in two directions at the ſame time. If five hundred projections, all in different directions, were applied at the ſame time, the projectile would fall into one courſe, common to them all.

Add to this, that if there can be no real motion, in an adverſe direction to abſolute motion, unleſs there be a deſtruction, or at leaſt weakening of this vis inertiæ, which is ſuppoſed to be the principle that continues abſolute motion; then the projectile courſe of the moon round the earth, muſt ſoon deſtroy her abſolute motion. For every month the moon for near 500,000 miles, ſtruggles in a courſe, which is in effect, diametrically oppoſite to the vis inertiæ, carrying her in another direction. And this cannot happen without continually weakening, and at laſt wholly deſtroying it.

For theſe reaſons, unleſs I can ſee them fairly removed, I muſt conclude, that even ſuppoſing theſe principles, aſſumed by the preſent philoſophy, are real, yet it is impoſſible to explain the celeſtial motions by them.

CHAP.

CHAP. III.

Of the Properties that are common to all Bodies, and of the Elements of Natural Bodies.

1. *Of Extenſion.*
2. *Of a Vacuum.*
3. *Of Solidity.*
4. *Of Diviſibility.*
5. *Of Motion and Reſt.*
6. *Of the Laws of Motion.*
7. *Of the Ariſtotelic Elements.*
8. *Of the Principles of the Chymiſts.*
9. *Objections to them.*
10. *What is the primary Element of all Things.*

1. HAVING ſpoken of the particular ſpecies of bodies, it remains only to ſpeak of bodies in general. And it may be obſerved of them all, that they are extended, ſolid, diviſible, figured, and capable of motion. We cannot conceive any body that is not extended, or compoſed of ſeveral parts. And yet we cannot affirm, that the eſſence of body conſiſts in this alone.

2. For there may be extenſion without body, which is uſually termed ſpace or a vacuum. Theſe are widely different from each other. Body is diviſible and ſeparable into parts, and conſequently capable of motion; none of which can be ſaid of mere ſpace. And that there is empty ſpace is clear from hence. That if all were full, there could be no motion in the world. For in

in order to this it is requiſite that each particle leave its place empty for another to fill. It is ſaid indeed, this need not be, becauſe all motion is circular, ſo that in every motion of whatever kind, each part of the body moved, ſucceeds another. But this is abſolutely contrary to matter of fact. We ſee with our eyes, that all motion is not circular. And if not, then there muſt be empty ſpace, or there could be no motion at all.

3. Another property of body is ſolidity, whereby it reſiſts another body, moving it out of its place. Not much different from this, is impenetrability, whereby a body excludes another from the place where it is. Solidity is not the ſame with hardneſs, the former belonging to all, the latter to ſome bodies only. Hardneſs conſiſts in the firm coheſion of the parts, ſo as not eaſily to be ſeparated. As the ſolidity of bodies flows from the intrinſic nature of matter, it is vain to aſſign as the cauſe of it, either the figure or reſt of the parts, or the preſſure of the air, or of ſome ſubtle matter. By theſe ſolutions we do not at all explain the thing, but only entangle ourſelves in freſh difficulties.

4. Diviſibility likewiſe belongs to all bodies. For ſince no body can be conceived that is not extended, and extenſion ſuppoſes parts, it follows, that every body, however ſmall, is diviſible: perhaps not by the art of man, but in its own nature. Nor is it any objection, that our underſtanding cannot comprehend infinite diviſibility. It cannot: nor can it comprehend infinite number; or indeed infinites of any kind.

It is true, there is no ſuch thing, ſtrictly ſpeaking, as parts infinitely ſmall. Yet the ſmallneſs of the particles of ſeveral bodies, is ſuch as vaſtly ſurpaſſes our conception. And there are innumerable inſtances in nature of ſuch parts actually ſeparated from each other.

Mr. Boyle gives us ſeveral inſtances of this. He ſpeaks of a ſilken thread, three hundred yards long, that weighed but two grains and a half. Fifty ſquare inches of leaf-gold weighed but one grain. Now if the length of an inch be divided into two hundred parts, the

the eye may diſtinguiſh them all. Therefore there are in one ſquare inch forty thouſand viſible parts, and in one grain of leaf-gold, two millions of ſuch parts: which viſible parts no one will deny to be farther diviſible. In odoriferous bodies, we may diſcern a ſtill greater ſubtlety of parts, yea, of parts actually ſeparated from each other. Several bodies ſcarce loſe any thing of their weight in a long time, and yet continually fill a large ſpace with odoriferous particles. Several animals are but juſt viſible with the fineſt microſcope. And yet theſe have all the parts neceſſary for life, as blood and other juices. How wonderful muſt the ſubtlety of the parts be, whereof thoſe fluids are compoſed. And hence the following ſtrange theorem is deduced and demonſtrated by Dr. Keil. "Any particle of matter, how ſmall ſoever, and any finite ſpace, how large ſoever, being given, it is poſſible for that particle to be diffuſed through all that ſpace, and to fill it in ſuch a manner, that there ſhall be no pore in it, whoſe diameter ſhall exceed any given line."

5. The laſt general property of matter is motion and reſt. For it is plain, all matter is either at reſt or in motion. God is the firſt and univerſal cauſe of motion, as well as of all things. The immediate cauſe of it, is either matter or ſpirit. It is beyond doubt, that a body moved, communicates its motion to another, though in its own nature it be purely paſſive. Nor can we reaſonably deny that a ſpirit is able to move matter, although the manner of its doing this we cannot comprehend.

6. All the laws of motion may be reduced to three. 1. Every moving body is moved by another: 2. Every moving body communicates its motion to any body it meets: 3. Every moving body continues in motion, till it communicates that motion to another. While theſe laws remain in force, and concur in producing various effects: thoſe effects are termed natural. When any of theſe laws are ſuſpended, this is properly a miracle.

7. As

7. As the elements or firſt ſtamina of bodies are too ſmall to be diſcerned by any of our ſenſes, we can only form conjectures concerning them. The moſt probable conjectures are theſe. Empedocles, and Ariſtotle from him, ſuppoſed, there are four elements, fire, air, water and earth. And indeed this diviſion ſeems to be grounded on the nature of things: for there is no doubt but at the creation of this globe, the confuſed maſs was ſeparated into four parts, the heavieſt of which conſtituted the earth, the particles next in weight the water, the third, lighter ſtill, air, and the lighteſt of all, fire, otherwiſe termed ether. And it is manifeſt, all bodies known to us, are reducible to one or more of theſe. Every thing corporeal is either earth, air, water or fire, or compounded of them. So that after all the diſquiſitions of two or three thouſand years, this eaſy, plain, natural account of the elements, is not likely to be amended: it being a certain fact, that of theſe do all bodies conſiſt.

8. The Chymiſts have taken another way, endeavouring to trace the principle of bodies, not by the ordinary uſe of their ſenſes, nor by reaſoning, but from experiments made by fire. And by this means they make five elements. For whatever is diſtilled, firſt emits a ſapid and ſpirituous vapour, which is by cold condenſed into a liquor: and this they term mercury: then an inſipid liquor, which they called phlegm: afterward an acid liquor, which is alſo termed mercury. A thicker and oily liquor comes next, which becauſe eaſily inflammable, is ſtiled ſulphur. The ſalt which is afterwards found is their fourth element, the inſipid earth, which is left, the fifth.

9. But not to inſiſt, that all bodies are not reſolvible into theſe principles, it is utterly uncertain, whether fire does not alter the natural qualities of bodies, and introduce other qualities into them, which they had not before. Beſides ſome of theſe are not ſimple elements. They are compounded of others, oils and ſalts in particular. Therefore neither are all thoſe oils and ſalts of one ſort, but

but as various as the bodies from which they are extracted. In truth, these are at most the constituent parts of two of the Aristotelic elements, namely water and earth: but the two others, air and fire, are quite omitted in their account.

10. Perhaps one might rather term matter itself, with its general properties, the first and most simple element, out of which all things are compounded. But the particles of this are not fit to compose the immediate stamina of larger bodies, till they combine together into oils, salts, and juices of various kinds. And hence arise those principles of the Chymists, of which most bodies are compounded: although still they are only secondary elements, as being themselves compounded. Indeed it seems probable, God in the beginning formed matter in solid, impenetrable, moveable particles, of such sizes and figures as most conduced to the end for which he formed them: and that these primitive bodies are incomparably harder than any porous bodies compounded of them: even so hard as never to wear out, no natural power being able to divide them. And thus remaining entire, they compose bodies of the same nature and texture in all ages: whereas should these wear away, or break in pieces, the nature of things depending on them would be changed. Nor would water and earth, composed of broken, worn-out particles, be the same as they were at the beginning. But they are the same in all ages: and the changes of things do not imply any change in those original particles, but only various associations and separations of them. Nor do compound bodies ever break in the middle of solid particles, but where those particles are joined together, and only touch in a few points.

CHAP. IV.

Of those Things wherein Natural Bodies differ.

1. *Of the particular Properties of Bodies.*
2. *Of Light.*
3. *Of Colours.*
4. *Of Sounds.*
5. *Of Smells.*
6. *Of Taſtes.*
7. *Of Moiſture and Dryneſs; Heat and Cold.*
8. *Of Gravity.*
9. *Of the other Properties of Bodies.*
10. *Of occult Qualities.*
11. *Reflections.*

1. HAVING conſidered wherein natural bodies agree, we come now to conſider, the particular properties wherein they diſagree, and whereby they are diſtinguiſhed from each other. Thoſe of them, which are perceived by our outward ſenſes, are divided accordingly into various claſſes, as they affect the ſenſe of ſight, of hearing, of taſting, of ſmelling, or of feeling.

2. Light ſeems to be one of the moſt ſubtle bodies in the univerſe. The grand reſervoir thereof is the ſun: but it is likewiſe emitted by many other bodies, and by almoſt all, when they are on fire. When it falls on any body which it cannot paſs through, and ſo is beat back, it is ſaid to be reflected. But when it paſſes from one tranſparent body into another, which is either rarer

or

or denſer, it moves obliquely, its rays being bent, and is ſaid to be refracted. When it paſſes through a body in ſtrait lines, it is ſaid to be tranſmitted. Thoſe which emit the light are termed lucid bodies; thoſe which reflect it opaque.

The particles of light, minute as they are, are attracted by thoſe of other bodies. Hence in their paſſage near the edges of bodies, whether opaque or tranſparent, they are diverted from the right lines, and reflected towards thoſe bodies. This action of bodies on light exerts itſelf at ſome diſtance, but increaſes as the diſtance is diminiſhed: as appears in the paſſage of a ray between the edges of two thin plates, at different apertures in which it is peculiar, that the attraction of one edge is increaſed, as the other is brought nearer it. The rays of light paſſing out of glaſs into a vacuum, are not only inflected toward the glaſs, but if they fall too obliquely, they will revert back to the glaſs, and be totally reflected. This reflection cannot be owing to any reſiſtance of the vacuum, but merely to the attracting power of the glaſs. This appears farther from hence: if you wet the poſterior ſurface of the glaſs, the rays, which would otherwiſe have been reflected, will paſs into and through that liquor: which ſhews that the rays are not reflected, till they come to that poſterior ſurface of the glaſs; nor even till they begin to go out of it. For if at their going out, they fall into any liquor, they are not reflected, but perſiſt in their courſe, the attraction of the liquor counterbalancing that of the glaſs.

From this mutual attraction between the particles of light and other bodies, ariſes the reflection and refraction of light. The determination of any moving body is changed, by the interpoſal of another body. Thus light meeting any ſolid body, is turned out of its way, and reflected: but with this peculiar circumſtance; it is not reflected from the body itſelf, but by ſomething diffuſed over the ſurface of that body, before it touches it. It is the ſame thing in refraction. The rays refracted come very near the refracting body; yet do not touch it. Thoſe that actually touch ſolid bodies,

dies, adhere to them, and are as it were extinguiſhed and loſt.

This entirely agrees with the curious obſervation of an ingenious writer. "It is common to admire the luſtre of the drops of rain, that lie on the leaves of coleworts and ſome other vegetables. Upon inſpecting them narrrowly, I find the luſtre riſes from a copious reflection of the light, from the flattened parts of its ſurface, contiguous to the plant. When the drop rolls along a part which has been wetted, it immediately loſes all its luſtre. The green plant being then ſeen clearly through it, whereas in the other caſe it is hardly to be diſcerned.

From theſe two obſervations laid together, we may conclude, the drop, when it has the luſtre, does not really touch the plant, but hangs in the air at ſome diſtance from it, by the force of a repulſive power. For there could not be ſo copious a reflection of light from its under ſurface, unleſs there were a real interval between it and the ſurface of the plant.

Now if that ſurface were perfectly ſmooth, the under ſurface of the drop would be ſo likewiſe, and would therefore reflect the image of the illuminating body, like a piece of poliſhed ſilver. But as it is rough, the under ſurface of the drop becomes rough likewiſe; and ſo reflecting the light copiouſly in different directions, aſſumes the colour of unpoliſhed ſilver."

Again. - Rays paſſing from a more rare into a more denſe medium, are turned out of their right line, becauſe more ſtrongly attracted by the denſer medium.

Rays of light differ in reſpect of refraction, reflection and colour. Thoſe that agree in the firſt of theſe, agree in all, and may therefore be termed homogeneal. Colours exhibited by them we may call homogeneal colours. This being premiſed, we may obſerve, 1. That the ſun's light conſiſts of rays variouſly refrangible: 2. The rays variouſly refrangible, when ſeparated from each other, exhibit different colours: 3 That there are as many ſimple, homogeneal colours, as there degrees of refrangibility: 4. A compoſition of all the ſimple colours, is requiſite to conſtitute white-

neſs:

neſs: 5. The rays of light do not act upon one another, in paſſing through the ſame medium: 6. Neither do they thereby ſuffer any refraction: 7. The ſun's rays contain all homogenous colours, which may therefore be called primitive.

As ſome rays of light are leſs than others, ſo they are more refrangible. Thoſe which are moſt refrangible, conſtitute violet colour: that is, the ſmalleſt rays excite the moſt languid colour. Thoſe which are largeſt, and ſo leaſt refrangible, conſtitute red, the moſt vivid colour. The other rays excite intermediate ſenſations, according to their reſpective ſize and refrangibility.

Bodies reflect, inſtead of tranſmitting light, that is, are opaque, not tranſparent, not for want of pores; but either becauſe of the unequal denſity of their parts, or the magnitude of their pores. Either their pores are empty, or they are filled with matter of a different kind, whereby the rays are variouſly refracted and reflected, till they are quite abſorbed.

Hence paper and wood are opaque, while glaſs is tranſparent. For in the confines of parts alike in denſity (ſuch as thoſe of glaſs and water) there ariſes no refraction or reflection, by reaſon of the equal attraction every way; ſo that the rays which enter the firſt ſurface, paſs ſtrait through the body. But in the parts of wood and paper, which are unequal in denſity, and contain much air in their large pores, the refractions and reflections are very great; ſo that the rays cannot paſs through them, but are bandied about till they are extinguiſhed.

Hence opaque bodies become tranſparent, when their pores are filled with a ſubſtance of equal denſity: as paper dipped in water or oil. And on the contrary, tranſparent bodies, by emptying their pores, or ſeparating their parts, become opaque. Thus ſalts and wet paper become opaque by drying, glaſs by pulverizing. Yea, water itſelf, if beat into froth, loſes its tranſparency.

That light is corporeal, cannot now be doubted, having been proved by a thouſand experiments. By reflection

reflection and refraction it may be turned more or leſs out of its way, according to the different denſities of the reflecting or refracting medium. Its rays in their progreſſive motion may be intercepted by the interpoſal of any opaque object. And when this is removed, they proceed again, in the ſame ſtrait courſe as before. They may likewiſe be contracted into a leſs, or diffuſed through a larger ſpace, while the quantity of light continues the ſame, neither increaſed nor diminiſhed. So in the focus of a burning glaſs, all the rays which would otherwiſe paſs directly through the glaſs, are contracted into one bright ſpot, while the circumambient ſpace, for the breadth of the glaſs, is deprived of its light, and left ſhaded. And the action of light thus condenſed, is proportional to its quantity, and produces all the effects of the moſt intenſe fire, yea, ſuch as no culinary fire will produce. Whence it is plain, that fire and light are eſſentially the ſame, and that fire is only condenſed light.

The materiality of light is farther confirmed by its motion. For viſion is propagated through this medium ſucceſſively, as ſound is through air. This has been demonſtrated from the eclipſes of Jupiter's ſatellites. For the ſatellite having been hid behind the planet, it requires a certain time, after it emerges, before its light can reach the eye, namely ſeven minutes and a half: which is a motion ſix hundred thouſand times ſwifter than that of ſound through the air.

The quantity of elementary light, is cœteris paribus, every where the ſame at the ſame diſtance from the ſun. But its action is more or leſs intenſe, as the rays are more direct or oblique. Theſe are in a continual vibrating motion, going and returning to and from the reſiſting medium, in exceeding ſhort and imperceptible intervals, which makes the element ſeem to be at perfect reſt. All the rays are refracted and reflected alternately; ſo that the ſame incident ray, which is refracted at one interval, is reflected at the next. This is viſible in tranſparent mediums, where the rays fall upon glaſs, water and the like. But in opaque bodies,

dies, though the fact is the ſame, it is not ſo ſenſible. When the rays fall upon glaſs, they are reflected one moment, and tranſmitted the next. And this vibrating motion ſeems to be eſſential to light, when its rays are put into motion.

In talking of light and ſound, we are apt to confound the ſenſation with the motion of the medium that excites it. Thus in a deep calm we ſay, there is no air, becauſe we feel none: though there is really the ſame quantity of air in equal ſpace, as if it blew a ſtorm. And ſo in deep darkneſs we ſay, there is no light in the room: although there is ſuppoſed to be as much light there, as was at noon day. Only its rays are quieſcent, and make no impreſſion upon the viſive organs.

Sound is ſaid to move about fourteen miles in a minute, which is performed thus. The ſtroke given by the ſounding body to the contiguous air, is communicated to the next, and ſo on till it reaches the ear.

The oſcillations of the air are required to ſucceed each other with a certain velocity; and in order to render them audible, they muſt not be fewer than thirty in a ſecond of time. But the more frequent theſe ſonorous wave are in a given time, the ſharper is the ſound heard, and the more ſtrongly does it affect us; till we come to the moſt acute of audible ſounds, which have 7520 tremors in a ſecond.

Acute ſounds are, in general, yielded from bodies that are hard, brittle and violently ſhook or ſtruck; grave ſounds are from the contrary. Cords or other bodies, that yield the ſame number of vibrations in a given time, are ſaid to be uniſon; as thoſe which make double the number of oſcillations in that time, yield a tone that is an octave, or eight notes higher; and other proportions betwixt the number of the vibrations, have different names aſſigned to them in a muſical ſcale. The ſhorter cords produce ſharper tones, and the reverſe in a proportion directly as their lengths;

alſo

alſo thoſe, which are more ſtretched, afford ſharper ſounds.

The ſound whether acute or grave, ſtrong or weak, is carried through the air about 1038 Paris feet in a ſecond, and that with an uniform velocity, without abating in the larger diſtances. But a contrary wind, cauſing the vibrations to extend more ſlowly, retards the progreſſion of ſound about one-twelfth of its velocity. Denſity and dryneſs of the air increaſe the ſound, as the rarefaction and moiſture of the air leſſen it. Hence in ſummer time, ſound moves ſwifter; and in Guinea, it has been obſerved to paſs at the rate of 1398 Pariſian feet in one ſecond.

Plutarch ſays, deers and horſes are of all irrational creatures, the moſt affected with muſic. Mr. Playford ſays the ſame thing, and adds, "Myſelf, as I travelled ſome years ſince, near Royſton, met about twenty ſtags upon the road following a bagpipe and violin; which when the muſic played went forward, when it ceaſed, they all ſtood ſtill. And in this manner they were brought from Yorkſhire to Hampton Court. Lions likewiſe, and elephants are ſuſceptible of the powers of muſic. So are many dogs, and moſt, if not all ſinging birds." A late author gives a ſtranger account ſtill.

Monſieur de ———, Captain of the regiment of Navarre, was confined in priſon ſix months. He begged leave of the governor that he might ſend for his lute. After four days he was aſtoniſhed, to ſee at the time of his playing, the mice come out of their holes, and the ſpiders deſcend from their webs, which came and formed a circle round him, to hear him with attention. This at firſt ſo ſurpriſed him, that he left off, on which they all retired quietly into their lodgings. It was ſix days before he recovered from his aſtoniſhment. He then began to play again. They came again, and in ſtill increaſing numbers, till after a time he found a hundred of them about him.

I ſaw a very large and fierce lion which was then kept

kept at the Infirmary at Edinburgh, quite tranſported with the ſound of a bagpipe, and rolling upon its back with the utmoſt ſatisfaction. I ſaw likewiſe the old lion, in the tower of London liſten with the utmoſt attention to a German flute. Mean time a young tigre leaped up and down inceſſantly, till the muſic ceaſed. So it may be literally true,

Suetus Amphion lenire tigres.

Light is propagated about two hundred thouſand miles in a ſecond, after the very ſame manner as ſound. The ſun impreſſes the contiguous part of its viſive atmoſphere: (light ſeems to be the atmoſphere of the ſun, as air is of all opaque bodies.) That part impreſſes the next, and ſo on, till it reaches the eye.

All ſenſation is from contact of feeling. And when the object is not in immediate contact with the organ it affects, touches, or impreſſes, by an interpoſed medium. By this means the ſoul perceives or feels the object by the proper organ. And thus, ſeeing is in effect, the feeling of the eye; hearing, the feeling of the ear.

From all our experiments it appears, that the particles of light are extremely minute. Probably they are the very ſmalleſt and laſt diviſions of matter, which being perfectly ſolid, cannot receive any other form. So minute are they as to paſs freely even through the pores of glaſs, which no other fluid can penetrate.

All other bodies are immerſed in this univerſal fluid, the common medium of all their actions on each other. But amidſt all the changes of compound bodies, all the forms they ſucceſſively put on, this ſimple element remains for ever fixed and immutable.

As to fire or condenſed light, all bodies whatever fly or recede from it, in proportion to its denſity: and this ſeems to be its firſt and moſt eſſential property, that no other body can exiſt with it, or bear its immediate action. So far as it prevails, it diſſolves the cloſeſt

and ſtrongeſt coheſion of parts in all other bodies, and reduces them into ſo extremely minute particles, that they evaporate in air. And herein is an eſſential difference, between this and all other diſſolvents in nature, that the ſubſtance diſſolved cannot unite with the diſſolvent, without deſtroying its action.

When ſalt diſſolves in water, iron in aqua fortis, or gold in aqua regia, the ſubſtance diſſolved is equally diffuſed through the diſſolvent, ſo as to incorporate with it. But none of the things diſſolved by fire, can mix or incorporate with it. They all fly off in vapour; otherwiſe the fire is preſently extinguiſhed.

Elementary light then, the rays of which when condenſed, take the name of fire, is an element of a peculiar kind, not ſubject to the mechanical laws of other bodies. Now if we ſuppoſe a material fluid, void of gravity, preſſure, or any other mechanical power, all gravitating bodies will move through ſuch a fluid, as freely as in vacuo.

Elementary light is a material fluid, void of gravity, preſſure or any other mechanical power. When condenſed, it is pure, elementary fire, which excludes all other matter out of the ſame ſpace. Yet it lies in the focus of a burning glaſs, perfectly ſtill and quieſcent. Though it is ſurrounded by the air, which is a gravitating fluid, preſſing equally every way, yet this immechanical element is not at all affected by it, ſo as to riſe or fall in it, or in the leaſt to alter its ſtate, either of reſt or motion, which muſt neceſſarily happen, were it endued with gravity, or the other mechanical properties found in other bodies.

And that the rays of light, in their progreſſive motion, do not preſs, reſiſt, attract, or at all diſturb each other, is evident from facts though they come from every point of ſpace, that can be within the optic angle of the eye. Thus two men ſtanding at a diſtance, and looking at each other, ſee one another at the ſame inſtant, and that by means of rays, which act in contrary directions, without the leaſt reſiſtance. And any number of other men, ſtanding in any poſition, may

ſee

ſee the ſame men in the ſame inſtant, by rays which croſs each other without any interruption, in all poſſible angles. But in ſounds which move through a gravitating, reſiſting medium, the caſe is quite different. For a multitude of ſounds, from different ſonorous bodies, cannot be diſtinctly heard: particularly, when they come to the ear, in many different directions. For the undalations of the reſiſting medium, mixing with, and diſturbing each other, confuſe the ſenſation, throwing all together, indiſcriminately to the ear. Thus when a multitude of people are all talking together, the ear receives only a confuſed hum or murmur; whereas the eye can perceive all or any one of them diſtinctly and without confuſion.

Indeed nothing is more ſure, than that gravity, preſſure, reſiſtance, and all thoſe affections of bodies which are termed their mechanical powers, are not intrinſic or eſſential to them. For ſince matter is purely paſſive, and can only act as it is acted upon, it follows, that the active force or energy, which we obſerve through the whole material ſyſtem, muſt be the effect of ſome intrinſic, or eſſential cauſe. And ſuch a cauſe is light. But then the actions of this can never be mechanically accounted for. How this immechanical fluid acts upon other bodies, and determines their mechanical powers, we can no more explain than how the ſoul acts upon the body, or the mind upon matter. But we are ſure this is not done by weight, preſſure, reſiſtance, or any mechanical property whatever.

"But what are the general laws of nature?" They are plainly the rules or principles, by which the Governor and Director of all things, has determined to act. Accordingly what we call mechaniſm, is indeed the free agency and continued energy of the Author and Director of nature. All the neceſſary motion of bodies therefore, and all the laws and forces, whereby it is communicated and preſerved, are the continued, regular will, choice and agency of the Firſt Cauſe, and inceſſant Mover and Preſerver of the univerſe.

By the help of this admirable, this firſt made, be-

 cauſe

cauſe moſt neceſſary creature, light, all the animal world is enabled to go here and there, as their occaſions call. We can with pleaſure behold the glorious works of God: we can view the glories of the heavens, the beauties of the flowery fields, the gay attire and exquiſite garniture of many creatures. We can with admiration ſee the great Creator's wonderful art in the parts of animals and vegetables. In a word, we can behold the harmony of this lower world, and of the globes above, and ſurvey his exquiſite workmanſhip in every creature.

IV.

It is a great inſtance of his providence, that ſo neceſſary as light is, it is not long in paſſing from place to place. How inconvenient would it be, were the motion of it no ſwifter, than that of the ſwifteſt bodies on earth, ſuch as of a bullet out of a great gun, or even of ſound itſelf? Did it move at the rate of the firſt, it would be above thirty-two years in coming from the ſun to us, (according to the common computation of the ſun's diſtance,) above ſeventeen years at the rate of the ſecond motion. The inconvenience of this would be, its energy would be greatly abated, its rays would be leſs penetrant, and darkneſs would be diſſipated, with greater difficulty, eſpecially by the fainter light of our ſublunary luminous bodies. But paſſing with that prodigious ſwiftneſs, (from the ſun to us in ſeven or eight minutes) we receive with ſecurity and ſpeed the kindly effects of that noble and uſeful creature.

Another thing worthy of conſideration is, the inconceivable extenſion of light. It is as unlimited as the univerſe itſelf, as is manifeſt from our ſeeing ſome of the moſt diſtant objects, the heavenly bodies, partly with the naked eye, partly with the help of inſtruments. And had we inſtruments of power equal to the extent of light, the luminous bodies in the utmoſt parts of the univerſe, would doubtleſs be viſible too. Hereby we have a ken of thoſe many glorious works of the infinite Creator, which we can improve to ſome

of

of the nobleſt ſciences, and moſt excellent uſes of our own globe.

One ſpecies of lucid bodies are termed Phoſphori: of which ſome are natural, others artificial. Natural phoſphori emit light without any art or preparation. Such are glow-worms, and ſeveral ſorts of ſhining inſects. Such are rotten wood: the eyes, blood, ſcales, fleſh and feathers of ſome animals. Diamonds likewiſe when rubbed emit light, to one who has ſtayed ſome time in the dark. But before the diamond is brought into the dark room, it ſhould lie eight or ten ſeconds in the ſun-ſhine. It will then ſhine in the dark twelve or thirteen minutes: but its light gradually weakens all the time.

But it is remarkable, that ſome diamonds have this property of imbibing the ſun's rays, and ſhining in the dark, and others not, though there is no other diſcernible difference between them. Nor is there any rule of judging, which diamonds have this property, and which have not. Their brightneſs, their purity, their ſize, their ſhape, contribute nothing to it.

Sulphur and ſugar when pounded in the dark, will likewiſe emit light; as will the backs of horſes or cats, when rubbed with the hand, and ſea-water, yea and ſome mineral waters, briſkly agitated. But no natural phoſphorus ſhines always, or gives any heat.

Artificial phoſphorus is made chiefly from human urine. But it may be made from blood, or hair; or indeed from any part of an animal, which yields an oily diſtillation. It is at firſt of the conſiſtence of hard wax; but diſſolves in all kinds of diſtilled oil. With ſolid phoſphorus one may write on paper as with a pencil, and the letters will ſhine in the dark. A little piece of it rubbed between two papers, takes fire preſently. It burns vehemently, and penetrates deeper into the fleſh than common fire. It never ſpoils, if kept in a phial full of water. Liquid phoſphorus does not keep long. If the face or hands be ſmeared with this,

this, they will ſhine in the dark, yet without any hurt to the ſkin.

If phoſphorus be put into a long phial, of which three fourths is filled with water, it will frequently ſend up corruſcations, which will pierce through the water, and expand themſelves with great brightneſs in the upper part of the phial.

If we compare this with lightning, we may obſerve, that as in this the fire paſſes alternately through the water, ſo in that the flaſhes, which come at intervals, paſs uninterrupted through the moſt denſe clouds and thickeſt rain. But this is uſually in warm weather, not in winter. And it is the ſame with phoſphorus. It very frequently flaſhes in warm weather, but very rarely in winter.

Again. The flame of lightning is generally inoffenſive, and does not ſet fire to any thing. In like manner the flaſhes of phoſphorus are harmleſs, and do not ſet fire to the moſt combuſtible matter. But when condenſed phoſphorus is ſet on fire, it burns terribly. And in the ſame manner lightning when condenſed, burns trees, houſes or whatever it comes near. Phoſphorus while burning, acts as a corroſive, and when it goes out, forms a menſtruum, which diſſolves gold, iron, and other metals. Lightning melts the ſame ſubſtances.

Another kind of artificial phoſphorus, is a preparation of the Bononian ſtone. This ſtone is of no certain figure, but is ſometimes round, ſometimes oblong, or lenticular. They are uſually as big as an orange, but very light, conſidering their bulk. They are of various colours, ſome aſh-coloured, ſome blue, and ſome almoſt white. When this ſtone is prepared, it receives light, but in very different degrees, either from the ſun, the moon, common day-light, or a flame. After it has been expoſed a few minutes to any of theſe, it ſhines in the dark like a burning coal, with ſuch a light as is ſufficient to read by, if the letters be held near the ſtone. It does not retain its light long, but requires often renewing. When well prepared, it will retain this virtue for five or ſix years. It appears to

moſt

moſt advantage, if brought into a dark room, after being held in the ſun.

3. When the rays of light fall on opaque bodies, they are variouſly reflected to our eyes, according as the ſurface of thoſe bodies are variouſly diſpoſed. And hence ariſes our ſenſation of colours. Theſe as they exiſt in the coloured bodies, are only the diſpoſitions of their ſurface, to reflect ſuch particular ſorts of rays. White bodies reflect all rays every way, without any ſeparation of them. On the contrary, black bodies imbibe all the rays, and reflect none or very few, whereas, blue, yellow, and red bodies, reflect only one particular ſort of rays. The ſmalleſt ſort of rays are ſuppoſed to be blue; the next yellow, the largeſt red.

To be a little more particular. There are eight true primary colours, which are red, yellow, green, blue, violet, purple, orange, and indigo. All the reſt are compounded of theſe, and are termed ſecondary colours. But the more compound any colour, the leſs vivid it is. And by too much compoſition they may be diluted and weakened till they are deſtroyed. The moſt extraordinary compoſition of all is that of whiteneſs. For to this five at leaſt of the primary colours are required, as alſo, that they be mixed in a certain degree. And hence white is the ordinary colour of light: light being an aſſemblage of all colours.

The tranſmutation of colours by mixing them together, is not real, but merely apparent. Thus mix blue and yellow powders, and they appear green. But view them with a microſcope, and the blue and yellow particles are ſeen as diſtinct from each other as before.

To produce black, the particles muſt be leſs than thoſe which exhibit any other colour. Where they are greater, there is too much light reflected to conſtitute this colour. But if there be a little leſs than forms the indigo, the body appears intenſely black.

And hence it appears, why fire and putrefaction turn many ſubſtances black. They divide them into exceeding ſmall particles, which then abſorb, inſtead of reflecting

reflecting the light. Hence alſo it appears, why glaſs ground very elaborately with ſand on a copper-plate, makes the ſand together with what is worn off from the glaſs and copper, become very black: likewiſe, why black ſubſtances expoſed to the ſun, are hot ſooner than any other. This may partly proceed from the multitude of refractions in a little room, partly from the eaſy commotion of ſo ſmall particles, and from their imbibing his rays. Hence alſo we learn, why blacks are uſually inclined to a bluiſh colour. Black borders on indigo, and therefore reflects indigo-rays, if any.

To try if black bodies receive heat more than others, Mr. Boyle whited one half of a tile, and blacked the other, and then expoſed it to the ſummer ſun. While the white part ſtill remained cool, the black part was grown very hot. For farther ſatisfaction he expoſed to the ſun a tile, part of which was blacked, part white, and part of its natural red: and after a while found the black part hot, the red warm, and the white cool.

"I laid on the ſnow, (ſays Dr. Franklin,) little pieces of broad cloth, of divers colours, black, deep blue, light blue, green, purple, red, yellow, white, in a bright ſun-ſhiny morning. In a few hours the black (being warmed moſt) was ſunk loweſt, the dark blue almoſt as low, the light blue not quite ſo much, the other colours leſs as they were lighter, and the white not at all. This was an eaſy and certain way of ſhewing which was heated moſt."

All the ſecondary colours of natural bodies proceed from their reflecting two or more ſorts of rays together, and abſorbing the reſt.

Glaſs, cryſtal, diamond, and other tranſparent bodies, loſe their tranſparency, and are white, when reduced to powder: the change of texture cauſing them to reflect the rays which before they tranſmit.

White loaf ſugar, melted over the fire, without water, firſt turns brown, afterwards black. And a ſingle grain of this tinges a quart of fair water with a beautiful yellow. Violets, roſes, carnations, and moſt flowers loſe their colour, by being long in the

the open air. And by the ſame means blue eſſential oil of camomile-flowers changes to a dirty green.

Many colours may be produced, deſtroyed, and regenerated, upon ſimple mixture. Let dried roſe-leaves ſtay awhile in ſpirits of wine, and they loſe their colour without tinging the liquor. But add a little oil of vitriol, and it turns red: put in a little urinous ſpirit, and the red changes to green, which by adding a little more oil of vitriol, turns to a red again.

Make a ſlight infuſion of bruiſed galls in water, ſo as not to diſcolour it. Make alſo a weak infuſion of green vitriol in water, which will be ſtill tranſparent. Yet mix them together, and an inky blackneſs will immediately ariſe. But add a little oil of vitriol, the blackneſs will vaniſh, and the liquor be tranſparent again. Yet the blackneſs may be recalled by adding a little ſalt of tartar.

If a little bruiſed camphire which is very white, be put into tranſparent oil of vitriol, the camphire will diſſolve, and tinge the liquor firſt brown, and at length a fine black. But upon the addition of fair water, the blackneſs entirely vaniſhes, and the camphire regains its native whiteneſs.

A tranſparent infuſion of ſugar of lead in water being wrote with, when dried becomes inviſible. But the bare fumes of another tranſparent liquor, namely, infuſion of quick lime and orpiment in water, will quickly make the inviſible writing black and viſible.

And not only ſecondary, but primary colours are producible by ſimple mixture. If the ſun's rays paſs through two pieces of differently coloured glaſs, ſuppoſe a blue and yellow piece laid on each other, and theſe rays are received upon white paper, they produce a beautiful green. A mixture of ſeven, or even, five original colours, will make a pure white. If different coloured flames be brought to mix, the experiment is made to perfection.

Flames from different bodies are of different colours. The flame of camphire is white; of ſulphur, blue; of white-wax, inclining to yellow. For making experiments, oil may be impregnated with different metals, ſo as to exhibit their particular flames.

4. Air is the ordinary vehicle of ſound, which is the fainter, the more remote the ſounding body is. It is alſo leſſened, and ſometimes quite interrupted either by contrary winds or thick vapours floating in the air. It is ſuppoſed, that the ſounding body, excites a kind of undulation or tremulous motion in the air, raiſing as it were waves of air, one of which impels the other till they reach the ear.

Sound moves but little quicker by having the wind with it, as it moves at leaſt thirty-three times faſter than the moſt violent wind we know. But it is heard much farther thereby.

That air is the grand vehicle of ſound, appears from various experiments. A bell in an unexhauſted receiver, may be heard at ſome diſtance: but ſcarce at the ſmalleſt, when it is exhauſted. But it is not the only one, water too will convey ſound. If you ſtrike a bell under water, the ſound is heard plain, only not ſo loud, and alſo a fourth deeper. And a ſound made in air, is heard under water, with juſt the ſame difference.

Sounds commonly move a mile in about nine ſeconds and quarter. If a gun be diſcharged with its mouth to us or from us, the report comes to us in the very ſame time. It always moves the neareſt way, and equally ſwift from the beginning to the end of its motion.

If the undulating air ſtrikes againſt hard, concave bodies, it rebounds, and occaſions what we call an echo. As often as ſound ſtrikes perpendicularly on a wall, behind which is any vault or arch, or even a parallel wall, ſo often it will be reverberated in nearly the ſame line. For a multiplied echo, there muſt be a number of walls and cavities, either behind, or fronting each other.

The echo in Woodſtock-park returns very diſtinctly, in the day ſeventeen, in the night, twenty ſyllables. There is an echo on the bank of the river Naſſa, between Bingen and Collentz in Germany, which repeats what is ſaid ſeventeen times. And what is ſtill more peculiar, the perſon who ſpeaks, is ſcarce heard at all, but the repetition clearly, and with ſurpriſing variety:

variety: the echo ſeeming ſometimes to approach nearer, and ſometimes to be farther off. One perſon hears only one voice, another ſeveral: one hears it on the right, another on the left.

Two miles from Milan there is a ſtill more ſurpriſing echo. It returns the ſound of a piſtol fifty-ſix times. The firſt repetitions follow one another very quick; but they are more diſtinct in proportion as they decay. There are two parallel walls, which beat the ſound back upon each other.

5. The fine effluvia from odorous bodies, when they reach our noſtrils, excite the ſenſation of ſmelling. Some bodies emit theſe moſt when they are moiſt: ſome only when they are warmed or heated. From all ſuch bodies innumerable particles flow, which according to their various ſize, figure, and motion, variouſly affect the olfactory-nerve. But what particular motion, ſize or figure, is required in order to any particular ſmell, who is able to explain?

Theſe effluvia indeed are inconceivably ſmall: ſo that amber and divers other odorous bodies, emit them for many years, without any diſcernable loſs, either as to bulk or weight.

Mr. Boyle ſhews, 1. That the number of particles thus emitted, is exceeding great. 2. That they are of a very penetrating nature. 3. That they move with vaſt ſwiftneſs and in all directions. 4. That there is often a wonderful congruity between the bulk and ſhape of theſe effluvia and the pores of the bodies they penetrate, and laſtly, that they may excite great motions, and thereby make great changes in organized bodies.

That effluvia are emitted to a very great diſtance we learn from hence, that wines grow turbid in the hogſhead, preciſely at the time that the grapes are ripe in the country whence they were imported. That they are very penetrating even without loſing their virtue we have a proof from the loadſtone, whoſe effluvia paſs through the moſt ſolid bodies, without any change of their force. That they occaſion great changes in organized bodies, we have a remarkable proof in a

caſe

caſe lately publiſhed by Dr. Heiſter, " Making an afternoon's viſit, to the reverend Mr. Sentag, he received me in an apartment where there were three or four flower-pots with white lillies. I aſked him, if he did not find his head affected, when he continued long in the room where they were, and told him, phyſicians thought them dangerous, and I myſelf could not bear them. I therefore begged the window might be opened, that the effluvia might be diſperſed.

" He ordered the window to be opened, and replied, He found no inconvenience from them, being a tall, ſtrong, healthy man. But the ſmell being ſtill too powerful for me, I was obliged to take my leave of him ſooner than I intended.

" The night following he was ſeized with an apoplexy. Dr. Bayer and myſelf were ſent for. We found him with his eyes wide open, but without ſpeech, ſenſe or motion. I told Dr. Bayer what had paſſed the day before. We ordered bleeding, bliſters, and ſtrong friction of the ſoles of the feet, head, and hands, with the other remedies uſual in thoſe caſes: but without ſucceſs; for the next morning he began to rattle in the throat, and ſoon after died."

This may admoniſh thoſe to whom theſe odours are not ſenſibly prejudicial, not to ſtay long within the ſphere of their activity.

In ſome places effluvia from the earth produce many effects on the ſurface of it. The bubbling and boiling fountains in England and other countries are chiefly occaſioned by the burſting up of their effluvia. Our burning well in Lancaſhire has no peculiar property in its water: but an inflammable vapour riſing through it, makes it boil and bubble on the ſurface. And this vapour, as ſoon as ſet at liberty from the water will take flame at a lighted candle.

The famous boiling ſpring near Montpelier, is likewiſe no other than common water, through which a vapour of the ſame kind makes its way. Indeed all the ſprings thereabouts, bubble more or leſs; the vapour making its way through the whole ſurface of the earth. Water taken out of that ſpring has no ſuch property, nor any peculiar taſte or virtue. What is a farther

proof

proof is, the cracks of the earth thereabouts, all perſpire ſtrongly a vapour of this kind: ſo that if ſtraws be laid on the ſurface, they will be blown up, and if a hole be any where dug in the ground, and water poured into it, it will boil up in the ſame manner as the ſpring.

The like ſort of ſprings are common in Switzerland, and ſome other places. Theſe are known to be owing to effluvia from beneath, by the water of them being cold. But there are others which actually boil, and are hot enough to boil an egg. Such are the famous boiling fountains, of Solfatara, near Naples.

From theſe various ſprings we find that there is much variety of this kind of exhalations: ſome being cold and dry: ſome of a bituminous nature, and not actually cold, as ours in Lancaſhire: ſome hot as thoſe in the ſweating vaults and caverns, and in the mountains of Italy. Others are of a poiſonous nature, containing particles of arſenic, or other poiſonous minerals.

6. Many bodies are taſteleſs. But ſome even of theſe may contract a very ſtrong taſte (as do ſeveral metals) when they are reſolved into a fine powder. Some bodies by ſeveral other changes, acquire taſtes, which they had not before, or variouſly increaſe, leſſen or alter their taſte. Hence it has been ſuppoſed, that all taſtes proceed from ſalts, which are often ſo enveloped, that they cannot exert their power. But if the containing bodies are diſſolved by fire or liquors, then they variouſly affect the nerves in the tongue and palate. And hence ariſe all the various ſenſations of taſte. But what particular ſize, ſhape or motion of the particles, is required to produce any particular taſte, all our ſkill cannot determine.

7. Of the properties which we perceive by feeling, the chief are moiſtneſs, dryneſs, heat and cold. There is no heat without fire, or at leaſt ſome diſpoſition of the heated body to take fire. If the particles of it, rapidly agitated, ſtrike againſt another body, they tear and diſſolve it: if againſt the body of a man, the ſenſation

ſation of heat ariſes in the mind. Some ſuppoſe, cold conſiſts in the reſt of thoſe particles which were ſo agitated before. Others think this would not ſuffice to produce that acute pain which we ſometimes feel from cold: and therefore ſuppoſe there are poſitive frigorific particles which move on in ſtrait lines, and ſo not only deſtroy the circular motion which is required for heat, but likewiſe penetrate the body, and ſharply affect the extremities of the nerves.

8. Gravity and levity have likewiſe been reckoned among ſenſible qualities. But properly, there is no ſuch a thing as levity, for all bodies tend to the centre of the earth, though ſome are light in compariſon of others. The laws of gravity are, 1. All bodies on the earth, tend to a point which is (nearly at leaſt) the centre of the globe. 2. In all places equidiſtant from the centre, the force of gravity is nearly equal. 3. Gravity equally affects all bodies, without regard either to their bulk or figure. So that were it not for the reſiſtance of the medium, the greateſt and ſmalleſt bodies, the moſt denſe, and the moſt rare, would deſcend equal ſpaces in equal times. Thus gold and feathers deſcend alike in an exhauſted receiver. 4. This power increaſes as we deſcend to the centre, and decreaſes as we aſcend from it: and that as the ſquares of the diſtances. Thus at a double diſtance, things have but a quarter of the force. 5. Thoſe things ſwim in fluids, which are ſpecifically (that is, bulk for bulk) lighter than thoſe fluids.

This gravitating power ſeems to be congenial to matter. It penetrates even to the centre of the ſun and other heavenly bodies, without any diminution of of its virtue. And it acts not according to the ſurface of bodies, as mechanical cauſes do, but according to the quantity of matter they contain. That it is an original law of nature, immediately impreſſed by the Creator, without dependance on any ſecond cauſe at all, may appear from the following conſiderations. 1. Gravity does not require the preſence of the gravitating or attracting body. 2. The diſtance being the ſame, the velocity wherewith gravitating bodies move, depends on the quantities of matter in the attracting

tracting body. And the velocity is not changed, let the maſs of the gravitating body be what it will. 3. If gravity depends on any known law of motion, it muſt be ſome impulſe from an extraneous body: whence, as gravity is continual, a continual ſtroke muſt alſo be required. Now if there be any ſuch matter continually ſtriking on bodies, it muſt be ſubtle enough to penetrate all bodies. But how ſhould matter, ſubtle enough to penetrate the hardeſt bodies, and ſo rare as not ſenſibly to hinder the motion of any, be able to impel ſuch vaſt bodies toward each other with ſuch force? How does this force increaſe, according as the maſs of that body, toward which any body moves increaſes? Whence is it, that all bodies at the ſame diſtance from the body gravitated to, move with the ſame velocity? And how can matter, which only acts on the ſurface of the bodies themſelves, or of their internal particles, communicate ſuch motion as in all bodies ſhall exactly follow the proportion of the quantity of matter in them?

But after all comes Mr. Hutchinſon, calls Sir Iſaac Newton and all his followers ſenſeleſs, unphiloſophical blockheads, and to ſolve all the difficulty in a moment, ſuppoſes the ſun to be the centre of the whole univerſe, and to project light every way, through every point of ſpace, to the utmoſt circumference of it. When this light arrives at the circumference, it is condenſed into larger maſſes, and returns in the form of ſpirit or air, through every point of ſpace to the ſun. There it is again comminuted into light by the immenſe fire, and ſo iſſues out again to the circumference. And this double impulſe of light moving outward, and ſpirit moving inward, cauſes the motion of all the heavenly bodies, both round their own axis and round the ſun. But to wave that groſs abſurdity, of ſuppoſing every point of ſpace to be continually filled with light, and every point of it to be filled with ſpirit at one and the ſame time, (which is flatly impoſſible, ſince both are material, and two particles of matter cannot co-exiſt in the ſame ſpace: how does this remove the difficulty at all? How does it help us forward a hair's breadth? For what impels light outward,

ward, or ſpirit inward? It can be no mechanical power. It muſt then be the finger of God. And if ſo, what have we gained? May we not as well ſay at once, (as go thus round about) "Gravitation can be no otherwiſe accounted for, than by allowing the direct, immediate power of God, operating through the whole univerſe."

But beſide the attraction of gravity, there is another ſpecies of attraction, between the minute particles whereof bodies are compoſed. Theſe attract each other at or near the point of contact, with a force much ſuperior to that of gravity. It is by this attraction of coheſion, that the atoms or inſenſible particles of bodies are united into ſenſible maſſes. Hereby numberleſs phenomena may be accounted for, which are otherwiſe inexplicable: ſuch as coagulation, cryſtallization, and the aſcent of fluids in capillary tubes. Such likewiſe are fermentation, animal ſecretion, and many others. Thus nature will be found very ſimple and conformable to herſelf, performing all the great motions of the heavenly bodies, by the attraction of gravity between thoſe bodies, and almoſt all the motions of their ſeveral parts, by this attraction diffuſed through every particle. Sir Iſaac thinks, that without theſe two principles there would be no motion in the world. And without the continual operation of them, it could not long continue, conſidering the vaſt and conſtant diminution of motion by various other cauſes.

Mr. Hervey's obſervations on this head, are ſtrong and beautiful.

"The fundamental laws of our modern aſtronomy are projection and attraction: one the all-combining cement, the other the ever-operative ſpring of the mighty frame. In the beginning God impreſſed a proper degree of motion on each of the whirling orbs. This, if not controlled, would have carried them on in ſtrait lines, till they were loſt in the abyſs of ſpace. But the principle of gravitation being added thereto, determined their courſe to a circular form. And how neceſſary

neceſſary for the conſervation of the univerſe, is both the one and the other? Were the projectile power to ceaſe, all the harmoniouſly-moving ſpheres would fall into the central fire. Were they gravitating, they would exorbitate into wild confuſion, or by their rapid whirl be diſſipated into atoms. But the impulſive and attractive energy, being nicely attempered to each other, the various globes perſevere in their radiant courſe, without any interruption or diminution.*

"How extenſive, and how diverſified is the force of this ſingle principle of attraction? (Underſtanding by the word, that of coheſion, as well as of gravitation!) It penetrates the very eſſence of all bodies, and diffuſes itſelf to the utmoſt limits of the mundane ſyſtem. By this all thoſe vaſt worlds of matter hang ſelf-balanced on their centres. And to this is owing an effect of a very different nature, the preſſure of the atmoſphere, which though a yielding and expanſive fluid, yet by virtue of an attracting energy ſurrounds the whole globe of earth, and encloſes every creature thereon, as it were with a tight bandage: an expedient abſolutely neceſſary to preſerve the texture of our bodies, and indeed of every animal. Urged by this, the rivers circulate with a never-failing current, along the veins of the earth. Impelled by the ſame myſterious force, the nutritious juices are detached from the ſoil, and aſcending the trunks of trees, find their way through millions of the fineſt meanders, in order to convey vegetative life into the ſmalleſt branches. This confines the ocean within its bounds. Though the waves thereof roar and ſwell, yet checked by this curb, they are unable to paſs, even the ſlighteſt barrier of ſand. To this the mountains owe that unſhaken firmneſs, which laughs at the ſhock of careering winds. By virtue of this inviſible mechaniſm, without any inſtrument of human device, thouſands of tons of water are raiſed every moment into the regions of the firmament. By this they continue ſuſpended in the air, without any ciſtern to contain them. By the ſame variouſly-acting power,

* All this is spoken on the Newtonian Hypothesis.

they

they in due time drop down again in gentle falls of dew, or are precipitated in copious ſhowers of rain. They ſlide down in fleecy flights of ſnow, or dart in clattering ſhowers of hail. This occaſions the ſtrong coheſion of ſolid bodies, without which our large machines would be utterly uſeleſs, and the nicer utenſils of life elude our expectations of ſervice. In ſhort, this is the ballaſt which compoſes the equilibrum, and conſtitutes the ſtability of things: this the great chain, which forms the connection of univerſal nature, and the mighty engine, which in good meaſure accompliſhes almoſt all her operations. What complicated effects from a ſingle cauſe! What profuſion amidſt frugality!"

How extremely plauſible is all this! And what pity, that it is only plauſible! But it is really no more: it is not capable of any ſubſtantial proof; I mean, with regard to the motion of the heavenly bodies, and the cauſes of that motion.

I do not know that any one has yet given a rational anſwer to Dr. Rogers' obſervations on that head. "The action of theſe two powers (gravitation and projection is inadequate to ſuch a motion: becauſe in order to produce it, the gravitating force muſt exactly balance the projectile. But were this done, one would deſtroy the other. This will appear plain, if we conſider the nature of theſe two forces. Gravitation, by which the earth attracts all bodies, is at all times uniformly exerted in right lines, from the earth to the body attracted, and acts equally on all bodies according to their denſities. It is perpetual, ſubject to no decay, needing no reparation. But projection is a motion given to the body, contrary to its nature. When given, it would always continue in a ſtrait line, if nothing hindered it; but cannot remove any obſtruction, without loſing part of its own force. Now the obſtruction given by attraction, muſt have the ſame effect as obſtruction given by air or ether: it muſt continually leſſen any projectile force, till that force is totally deſtroyed.

A mortar

A mortar elevated forty-five degrees, ejects a bomb at firſt in or near a right line, while the projectile force is vaſtly ſuperior to the attractive; afterwards in a curve: for the moment the two forces are in equilibrio, in a ſegment of a circle: then in a curve leſs and leſs bent, till it falls in a right line to the centre of gravitation.

This is the nature of all projectiles: nor can any projectile, thrown in any direction, by any force of attraction, produce a circular motion: much leſs an elliptical one, ſuch as that of the earth. Beſides, what phyſical reaſon can be aſſigned, why the earth, being nearer the ſun in winter, the gravitating force does not increaſe; and why the projectile does not increaſe in ſummer, when it is farther from the ſun, to the entire deſtruction of one or the other?

A third motion alſo is ſuppoſed to be primarily impreſſed on the earth, namely, round its own axis. But nothing can be more plain, than that a body ſo ſtrongly attracted by the ſun, as to keep it from flying off in a tangent, muſt have its circular motion preſently ſtopt: as the ſide next the ſun muſt be attracted moſt, the attraction of all the planets co-operating thereto.

To make this plain, I hung a loadſtone to a ſmall ſtring, and gave it as many turns as would continue its revolving motion ten minutes and a half, when no iron was near. But on bringing a piece of iron near, it ſtopped. The iron being removed, it recommenced its circular motion, which laſted for a minute more. Hence it is evident, that did not ſome force continually act upon the earth, to keep up its motions, the attractive power of the ſun would ſoon ſtop, at leaſt the diurnal one.

The friction likewiſe of the ether muſt be conſiderable. Elſe why might not the earth revolve in twenty-four minutes as well as twenty-four hours? Indeed this ſeems to be one great uſe of the ether, to prevent the too rapid motions of the planets. And as the earth

floats

floats in the air, ſo does the ſun in the ether, his proper atmoſphere, which extends to the utmoſt limits of his ſyſtem, and is the medium Funiculi or Hami, by which he attracts all the planets and comets, and prevents their flying out of the ſyſtem.

Neither will gravitation at all account for the motion of comets. That in 1680 deſcending from an immenſe height perpendicularly toward the ſun, roſe from him again with equal velocity. Now as its acceſs to, and receſs from the ſun, were made in ſtrait lines, while they were making, the projectile force muſt ceaſe. But to ſtop any projectile, is to deſtroy its motion. How came it then to be ſo ſtrongly exerted in the perihelion? Was there a continued miracle, a freſh projection given? Or did it rebound? What, from the yielding ether!

Again. This comet, during half its circuit round the ſun, was diſtant from it but one third of the moon's diſtance from the earth. The attractive force therefore was then vaſtly increaſed; and the projectile being deſtroyed, it muſt have impinged on the ſun long ago, had there been no other force to prevent it. It is clear then upon the whole, that the motions of the heavenly bodies, cannot be accounted for, by attraction and projection.

How then can they be accounted for? Poſſibly thus. The earth being an oblate ſpheroid, objected to the ſun in an obliquity of 66 degrees 30 minutes, (the ſame which given to the ſails of a windmill, occaſions its moſt forcible converſion) the ſun's rays ſtriking againſt the oblique hemiſphere, as the wind againſt the ſails of a windmill, keep it off, and at the ſame time make it turn on its own axis. The ether being a reſiſting medium, and the atmoſphere (like the oars of a boat) ſtriking therein, urges it into a progreſſive motion. Mean time its own gravity inclines it to the ſun's centre, and of courſe keeps it in equilibrio, with the repelling rays.

It

It is ſuppoſed likewiſe, that the plane of the earth's orbit, is in winter in or near the ſun's axis, whence the rays are not ſo forcibly emitted ; for which cauſe the earth muſt then come nearer, the repelling force being weaker. But in ſummer, being objected to the more forcibly repelling rays, it muſt be driven to a farther diſtance ; whence its annual orbit muſt become elliptical.

The earth's diameter being known, determines its diſtance from the ſun. For as the diameter is 7967, the periphery 25,031, which multiplied by the number of its revolutions 36,525, gives for its orbit 9,142,572: and as it moves through this orbit merely by the impulſe of the ſolar rays, and as the gravitating force muſt neceſſarily be equal to that impelling force ; ſo while it rolls onward one mile, it is attracted another. Conſequently the preceding orbit being doubled, by the gravitating force, make in all 18,285,144. The ſemidiameter of this is the diſtance of the earth from the ſun : which therefore is neither more nor leſs than 2,910,364 miles.

In the ſame manner we find the diſtance of venus from the ſun, to be 1,790,684 miles : that of mars, 5,473,690; that of Jupiter, 34,520,432 : that of ſaturn, 85,727,320 : and that of mercury, 700,758.

And as theſe diſtances are far leſs than thoſe aſſigned by the modern aſtronomers; ſo is the magnitude of the heavenly bodies proportionably leſs than they ſuppoſe. For inſtance : the diameter of the ſun, commonly ſuppoſed to be 822,148 miles, is according to this manner of calculating, 23,373 and no more. And that this is nearly the true diameter, and theſe the true diſtances, appears from experiments on the tranſits of the planets over the ſun."

The comets, Dr. Rogers thinks, are chiefly deſigned to repair the quantities of light continually emitted by the ſun, and which are ſcattered and diſperſed over the whole ſyſtem. Their ſweeping tails, which extend

ſo

ſo many thouſand miles, ſeem adapted to ſuch a purpoſe. And as many of thoſe particles of light, are driven to a vaſt diſtance, it is neceſſary they ſhould go to the utmoſt limits of the ſyſtem, to make ſuch a collection.

Suppoſe a body fit for this, detached from the neighbourhood of the ſun, it ſhould be light, porous, and ſpongy. And ſuch a body would be propelled by the violence of the rays, with great velocity to a great diſtance. The farther it goes, the fewer rays ſtrike upon it, and their force likewiſe is diminiſhed. The comet then ſlowly ſweeps his tail over the wide expanſe, beyond the orbit of ſaturn. There its cells are filled with the matter it was ſent to collect; but becoming heavier, the other ſcale begins to preponderate, and he ſlowly returns toward his centre. His collection increaſes as he deſcends, which adds to his weight and ſwiftneſs, and he comes down, if very heavy, almoſt in a ſtrait line; if leſs ſo, in a larger curve, till he is near the ſun, where having emptied himſelf, and being evenly balanced with the repelling rays, he moves round in the ſegment of a circle, till being continually lighter, he is no longer a balance for the repelling rays, and ſo is driven forward thereby, and runs the ſame circle as before.

What a violent blow is here given to the whole fabric of modern aſtronomy! And how can any reaſonable man ſubſcribe thereto, till this difficulty is removed?

9. There is no need to ſpeak particularly of thoſe other qualities, hardneſs, ſoftneſs; firmneſs, fluidity; brittleneſs, toughneſs; roughneſs, ſmoothneſs, denſity, rarity; rigidity, flexibility; compreſſibility, elaſticity. What each of theſe is, we know well, without any elaborate definition. And in general we know, that they all ariſe from the various figure, ſituation and texture of the particles whereof bodies conſiſt. But farther than this we know not. What particular

ſhape,

ſhape, texture, or ſituation, is requiſite in each caſe, is a matter of mere conjecture.

10. Thoſe of which we are not able to give any rational account, have often been termed occult qualities. Among theſe is uſually ranked that ſympathy, which is obſerved in things diſtant from each other. So onions in the granary ſprout, while others ſprout in the garden. So nothing is more common, than that if you throw a mulberry or ſtrawberry at a woman with child, the child has the mark of one or the other, on the ſame part which was ſtruck with it. And theſe marks grow green, yellow and red every year, juſt as thoſe fruits do in the garden. And when the ſeaſon of them is paſt, theſe ſubſide, and vaniſh away. So women ſtartled by a ſudden ſight of the moon, have ſtamped the figure of the moon on their children. And this figure increaſed or decreaſed juſt as the moon did. Oppoſite to this, is that amazing antipathy, which ſome things appear to have naturally for each other. Inſtances of which are found, not only in men, but in animals, if not in plants alſo.

Before we attempt to account for any of theſe things, we ſhould take care to be well aſſured of the fact. For many of them are generally believed and vehemently aſſerted, which yet never had any being. Hence others run into the oppoſite extreme, roundly denying whatever they cannot account for. The middle way is beſt. Firſt, be ſure of the fact. Then, try if it can be accounted for on allowed principles. And if it can, the qualities in queſtion, are to be termed occult no longer. But there will ſtill remain many ſecrets in nature, which we are in no wiſe able to account for. Indeed to penetrate the inmoſt receſſes of nature, is above the condition of humanity. We muſt therefore neceſſarily allow, that there are in this ſenſe many occult qualities: nay, we are ſurrounded with them on every ſide: inſomuch that there is ſcarce any thing in the univerſe, that has not ſome qualities, which the wiſeſt man on earth is not able to account for.

11. I have now finiſhed what I propoſed. I have given

given as ſhort and plain an account as I could, of all that is certain in Natural Philoſophy: in order to direct the whole to its proper end, I have now only to add a few reflections.

If we caſt our eyes up to the firmament, let us ſeriouſly aſk ourſelves, what power built over our heads that vaſt and magnificent arch, and ſpread out the heavens like a curtain? Who garniſhed theſe heavens with ſuch a variety of reſplendent objects, all floating in the liquid ether, and regular in their motions? Who painted the clouds with ſuch variety of colours, and in ſuch diverſity of ſhades and figures, as it is not in the power of the fineſt pencil on earth to emulate? Who formed the ſun of ſuch a determinate ſize, and placed it at ſuch a convenient diſtance, as not to ſcorch or annoy, but to cheriſh all things with his genial heat? For a ſucceſſion of ages he never failed to riſe at his appointed time, or to ſend out the dawn as his forerunner, to proclaim his approach. By whoſe ſkilful hand is it directed, in its diurnal and annual courſe, to give us the grateful viciſſitude of night and day, and the regular ſucceſſion of the ſeaſons? That it ſhould always proceed in the ſame path, and never once ſtep aſide: that it ſhould go on, in a ſpace where there is nothing to obſtruct, but turn at a determinate point; that the moon ſhould ſupply the abſence of the ſun, and remove the horror of the night; that it ſhould regulate the flux and reflux of the ſea, thereby preſerving the waters from putrefaction, andat the ſame time accommodating mankind with ſo manifold conveniences, that all the innumerable hoſts of heaven, ſhould perform their revolutions with ſuch exactneſs, as never once to fail, in a courſe of ſix thouſand years, but conſtantly to come about in the ſame round to the hundredth part of a minute: this is ſuch an inconteſtable proof of a Divine Architect, and of the care and wiſdom wherewith he governs the univerſe, as made the Roman philoſopher conclude, "Whoever imagines, that the wonderful order and incredible conſtancy of the heavenly bodies and their motions, whereon the welfare and preſervation of things depend, are not governed by an intelligent being, is himſelf deſtitute of underſtanding. For ſhall we,

when

when we ſee an artfully contrived engine, ſuppoſe a dial or ſphere, immediately acknowledge that it is the reſult of reaſon and underſtanding: and yet, when we behold the heavens, ſo admirably contrived, moved with ſuch incredible velocity, and finiſhing their anniverſary revolutions, with ſuch unerring conſtancy, make any doubt of their being the work, not only of reaſon, but of an excellent, a divine reaſon?"

But if from that very imperfect knowledge of aſtronomy which his time afforded, even the heathen could be ſo confident, that the heavenly bodies were framed and moved by a wiſe and underſtanding mind: what would he have ſaid, had he been acquainted with our modern diſcoveries? Had he known the immenſe greatneſs of that part of the world, which falls under our obſervation? The exquiſite regulation of the motions of the planets, without any deviation or confuſion: the inexpreſſible nicety of adjuſtment, in the velocity of the earth's annual motion; the wonderful proportion of its diurnal motion about its own axis; the denſities of the planets, exactly proportioned to their diſtances from the ſun: the admirable order of the ſeveral ſatellites, which move round their reſpective planets; the motion of the comets equally regular and periodical, with that of the other planetary bodies; and laſtly, the preſervation of the ſeveral planets and comets, from falling upon, or interfering with each other? Certainly could argument avail, atheiſm would now be utterly aſhamed to ſhew its head, and forced to acknowledge, that it was an Eternal and Almighty being, it was God alone, who gave to each of the celeſtial bodies, its proper magnitude and meaſure of heat, its dueneſs of diſtance, and regularity of motion: or in the language of the prophet, who "eſtabliſhed the world by his wiſdom, and ſtretched out the heavens by his underſtanding."

If from the firmament we deſcend to the orb on which we dwell, what a glorious proof have we of the Divine Wiſdom, in this intermediate expanſion of the air, which is ſo wonderfully contrived, to anſwer ſo

many important ends at once? It receives and ſupports clouds, to water the earth. It affords us winds, for health, for pleaſure, for a thouſand conveniencies: by its ſpring, it miniſters to the reſpiration of animals, by its motion to the conveyance of ſounds, and by its tranſparency, to the tranſmiſſion of light, from one end of heaven to the other. Whoſe power made ſo thin and fluid an element, a ſafe repoſitory for thunder and lightning? By whoſe command, and out of whoſe treaſuries, are theſe dreadful, yet uſeful meteors ſent forth, to purefy the air, which would otherwiſe ſtagnate, and conſume the vapours that would otherwiſe breed various diſeaſes? By what ſkilful hand are thoſe immenſe quantities of water, which are continually drawn from the ſea, by a natural diſtillation made freſh, ſent forth upon the wings of the wind, into the moſt diſtant countries, and diſtributed in ſhowers over the face of the earth?

Whoſe power and wiſdom was it that hanged the earth upon nothing, and gave it a ſpherical figure, the moſt commodious which could be deviſed, both for the conſiſtency of its parts, and the velocity of its motion? Who was it that weighed the mountains in ſcales, and the hills in a balance, and diſpoſed them in their moſt proper places, both for fruitfulneſs and health? Who diverſified the climates of the earth, into ſuch an agreeable variety, that, remote as they are from each other, each has its proper ſeaſons, day and night, winter and ſummer? Who was it that clothed the face of it with plants and flowers, ſo exquiſitely adorned with various and inimitable beauties? That placed the plant in the ſeed, in ſuch elegant complications, as afford at once both a pleaſing and an aſtoniſhing ſpectacle? That painted and perfumed the flowers, that gave them the ſweet odours which they diffuſe through the air for our delight, and with one and the ſame water dyed them into different colours, ſurpaſſing the imitation, nay, and the comprehenſion of mankind? For can the wiſeſt of men tell,

" Why does one climate and one ſoil endue
The bluſhing poppy with a crimſon hue,
Yet leave the lilly pale, and tinge the violet blue."

Who replenished the earth, the water, the air with such an infinite variety of living creatures, and so formed, that of the innumerable particulars wherein each creature differs from all others, every one is found upon examination, to have its singular beauty and peculiar use. Some walk, some creep, some fly, some swim. But every one has all its members and its various organs, accurately fitted for its peculiar motions. In short, the stateliness of the horse, and the feathers of the swan, the largeness of the elephant, and the smallness of the mite, are to a considerate mind equal demonstration of an infinite wisdom and power. Nay, rather the smaller the creature is, the more amazing is the workmanship. When in the mite, for instance, we see a head, a body, legs and feet, all as well proportioned as those of an elephant, and consider withal that in every part of this living atom, there are muscles, nerves, veins, arteries, and blood, every particle of which blood is composed of various other particles: when we consider all this, can we help being lost in wonder and astonishment? Can we refrain from crying out, on this account also, "O the depth of the riches both of the wisdom, and knowledge of God! How unsearchable are his works, and his ways of creation and providence past finding out!"

Natural instinct is another thing in animals, no less wonderful than their frame: and is indeed nothing else than the direction of an all-wise and all-powerful mind. What else teaches birds to build their nests, hard or soft, according to the constitution of their young? What else makes them keep so constantly in their nest, during the time of incubation, as if they knew the efficacy of their own warmth, and its aptness for animation? What else causes the salmon every year to come up a river, perhaps hundreds of miles, to cast its spawn, and secure it in banks of sand, till the young ones are excluded? To go no farther, can we behold the spiders net, the silk worms web, the bees cells, or the ants granaries, without being forced to acknowledge the infinite wisdom, which directs their unerring

ſteps, and has made them fit to be an emblem of art, induſtry and frugality to mankind?

If from the earth and the creatures that live upon it, we caſt our eyes upon the water, we ſoon perceive that had it been more or leſs rarefied, it had not been ſo proper for the uſe of man. And who gave it that juſt configuration of parts and exact degree of motion, which makes it ſo fluent, and yet ſo ſtrong as to carry, and waft away the moſt enormous burdens? Who has inſtructed the rivers to run in ſo many winding ſtreams, through vaſt tracts of land, in order to water them the more plentifully? Then to diſembogue themſelves into the ocean, ſo making it the common centre of commerce: and hence to return through the earth and air, to their fountain heads, in one perpetual circulation? Who repleniſhed theſe rivers with fiſh of all kinds, which glide through the limpid ſtreams, and run heedleſsly into the fiſher's net, for the entertainment of men? The great and wide ſea is a very awful and ſtupendous work of God. Whoſe hand makes it ebb and flow with ſuch exactneſs? A little more or leſs motion in the fluid maſs, would diſorder all nature, and a ſmall increaſe of tide, might ruin whole kingdoms. Who then was ſo wiſe as to take exact meaſures of thoſe immenſe bodies, and who ſo ſtrong as to rule at pleaſure the rage of that furious element? "He who hath placed the ſand for the bound of theſe, by a perpetual decree that it cannot paſs. So that though the waves thereof toſs themſelves, they cannot prevail, though they roar, they cannot paſs over it."

If from the world itſelf we turn our eyes more particularly on man, whom it hath pleaſed the Lord of all to appoint for its principal inhabitant, no underſtanding ſurely can be ſo low, no heart ſo ſtupid and inſenſible, as not plainly to ſee, that nothing but infinite wiſdom, could in ſo wonderful a manner have faſhioned his body, and breathed into it a reaſonable ſoul, whereby he "teacheth us more than the beaſts of the field, and maketh us wiſer than the fowls of heaven."

Should

Should any of us ſee a lump of clay riſe immediately from the ground, into the complete figure of a man, full of beauty and ſymmetry, and endowed with all the powers and faculties, which we perceive in ourſelves, yea, and that in a more eminent degree of perfection, than any of the preſent children of men: ſhould we preſently after obſerve him perform all the offices of life, ſenſe and reaſon; move as gracefully, talk as eloquently, reaſon as juſtly, and diſcharge every branch of duty, with as much accuracy as the moſt accompliſhed man breathing, how great muſt be our aſtoniſhment! Now this was the very caſe in that moment when God created man upon the earth.

But to impreſs this in a more lively manner upon the mind, let us ſuppoſe the figure above mentioned, riſes by degrees, and is finiſhed part by part in ſome ſucceſſion of time. When the whole is completed, the veins and arteries bored, the ſinews and tendons laid, the joints fitted, the blood and juices lodged in the veſſels prepared for them, God infuſes into it a vital principle. The image moves, it walks, it ſpeaks. Were we to ſee all this tranſacted before our eyes, we could not but be aſtoniſhed! A conſideration of this made David break out into that rapturous acknowledgement, "I will give thee thanks for I am fearfully and wonderfully made! Marvellous are thy works, and that my ſoul knoweth right well. Thine eyes did ſee my ſubſtance yet being imperfect, and in thy book were all my members written."

Thus which way ſoever we turn our eyes, whether we look upward or downward, without us, or within us, upon the animate or inanimate parts of the creation, we find abundant reaſon to ſay, "O Lord, how manifold are thy works! In wiſdom haſt thou made them all."

Let us obſerve a little farther the terraqueous globe. How admirably are all things thereon chained together, that they may all aim at the ultimate end, which God

God propoſed in all his words! And how vaſt a number of intermediate ends are ſubſervient to this! To perpetuate the eſtabliſhed courſe of nature, in a continued ſeries, the Divine Wiſdom has thought fit, that all living creatures ſhould conſtantly be employed in producing individuals; that all natural things ſhould lend a helping hand, toward preſerving every ſpecies, and laſtly, that the deſtruction of one thing ſhould always conduce to the production of another.

This globe contains what are called the three kingdoms of nature, the foſſile, vegetable, and animal. The foſſile conſtitutes the cruſt of the earth, lying beneath the viſible ſurface. The vegetable adorns the face of the globe, and draws much of its nouriſhment from the foſſile kingdom. The animal is almoſt wholly ſuſtained by the vegetable kingdom. If we go deeper into the earth, the rule which generally obtains with regard to the ſtrata thereof is this. The upper parts conſiſt of rag-ſtone, the next of ſlate, the third of marble filled with petrefactions, the fourth of ſlate again, and laſtly, the loweſt which we are able to diſcover, of free ſtone.

That the ſea once overſpread a far greater part of the earth, than it does at preſent, we learn not only from geographers, but from its yearly decreaſe, obſervable in many places: partly occaſioned by the vaſt quantities of ſhells and all kinds of rubbiſh, which the tides continually leave on the ſhores. Hence moſt ſhores are uſually full of wreck, of dead, teſtaceous animals, of ſtones, dirt or ſand of various kinds, and heaps of other things. Rivers likewiſe, eſpecially thoſe which have a rapid ſtream, wear away whatever they touch, particularly ſoft and friable earth, which they carry and depoſit on diſtant, winding ſhores: whence it is certain the ſea continually ſubſides, and the land gains no ſmall increaſe.

Water retained in low grounds occaſions marſhes. But what a wonderful proviſion has nature made, that

many

many of these even without the help of man, shall again become firm ground? More and more mossy tumps are seen therein. Some of these are brought down by the water, from the higher grounds adjoining, and others are produced by putrifying plants. Thus the marsh is dried up, and new meadows arise. And this is done in a shorter time, whenever the sphaguum, a kind of moss, has laid the foundation. For this in process of time, changes into a porous kind of mold, till almost all the marsh is filled with it. After this the rush begins to strike root, and together with the cotton-grass, constitutes a turf, wherein the roots get continually higher, and thus lay a firm foundation for other plants, till the whole marsh is covered with herbs and grass, and becomes a pleasant and fruitful meadow.

I shall add only one reflection more, with regard to the scale of beings. As the microscope discovers almost every drop of water, every blade of grass, every leaf, flower, and grain of earth, to be swarming with inhabitants: a thinking mind is naturally led to consider that part of the scale of beings, which descends lower and lower, from himself, to the lowest of all sensitive creatures. Among these some are so little above dead matter, that it is hard to determine whether they live or no. Others that are lifted one step higher, have no sense beside feeling and taste. Some again have the additional one of hearing: others of smell, and others of sight.

It is wonderful to observe, by what a gradual progression the world of life advances, through an immense variety of species, before a creature is found, that is complete in all its senses. And among these there are so many different degrees of perfection in the senses which one animal enjoys above another, that though each sense in different animals, comes under the same common denomination, yet it seems almost of a different nature. If after this, we attentively consider, the inward endowments of animals, their

their cunning and ſagacity, and what we uſually comprehend under the general name of inſtinct, we find them riſing one above another, in the ſame imperceptible manner, and receiving higher and higher improvements, according to the ſpecies in which they are implanted.

The whole progreſs of nature is ſo gradual, that the entire chaſm from a plant to man, is filled up with divers kinds of creatures, riſing one above another, by ſo gentle an aſcent, that the tranſitions from one ſpecies to another, are almoſt inſenſible. And the intermediate ſpace is ſo well huſbanded, that there is ſcarce a degree of perfection which does not appear in ſome. Now ſince the ſcale of being advances by ſuch regular ſteps as high as man, is it not probable, that it ſtill proceeds gradually upwards, through beings of a ſuperior nature? As there is an infinitely greater ſpace between the Supreme Being and man, than between man and the loweſt inſect.

This thought is thus enlarged upon by Mr. Locke. "That there ſhould be more ſpecies of intelligent creatures above us, than there are of ſenſible and material below us, is probable from hence, that in all the viſible and corporeal world, we ſee no chaſm, no gaps. All quite down from man, the deſcent is by eaſy ſteps: there is a continued ſeries of things that in each remove differ the leaſt that can be conceived from each other. There are fiſhes that have wings, and are not ſtrangers to the airy regions. And there are birds which are inhabitants of the waters, whoſe blood is as cold as that of fiſhes. There are animals ſo near a-kin both to birds and beaſts, that they are in the middle between both. Amphibious animals link the terreſtrial and aquatic together. Seals live either on land or in the ſea. Porpuſſes have the warm blood and entrails of a hog. There are brutes that ſeem to have as much kwowledge and reaſon, as ſome that are called men. Again: the animal and vegetable kingdoms are ſo cloſely joined, that between the loweſt of the one, and the higheſt of the other, there is ſcarce

any

any perceptible difference. And if we go on, till we come to the loweſt and moſt inorganical parts of matter, we ſhall find every where, that the ſeveral ſpecies are linked together, and differ in almoſt inſenſible degrees.

" Now when we conſider on the other hand, the infinite power and wiſdom of the Creator, does it not appear highly ſuitable to the magnificent harmony of the univerſe, and the infinite goodneſs of the architect, that the ſpecies of creatures ſhould alſo by gentle degrees aſcend upwards from us, (as they gradually deſcend from us downwards) toward his infinite perfection? And if ſo, is it not probable, there are far more ſpecies of creatures above than beneath us? Since we are infinitely more remote from the all-perfect Creator, than from the loweſt of all the works of his hands?

" But here our thoughts are loſt. We may conjecture a little; but we know nothing. However, it is enough, that we know the only true God, and Jeſus Chriſt whom he hath ſent."

This reflection upon the ſcale of beings, is purſued at large, by one of the fineſt writers of the age, Mr. Bonnet of Geneva, in that beautiful work, " The Contemplation of Nature." When I firſt read this, I deſigned to make only ſome extracts from it, to be inſerted under their proper heads. But upon farther conſideration, I judged it would be more agreeable, as well as profitable to the reader, to give an abridgment of the whole, that the admirable chain of reaſoning may be preſerved, and the adorable wiſdom and goodneſs of the great Author of nature, placed in the ſtrongeſt light.

INTRODUCTION.

I RAISE myself up to the Eternal Reason; I study his laws, and I adore him. I contemplate the universe with a philosophic eye. I search into the relations which by this immense chain constitute one whole. I stop a while to examine some links of it, and, struck with those marks of power, wisdom, and goodness which I discover therein, I faintly attempt their description.

CHAP. I.

Of the First Cause.

1. TO be ſelf-exiſtent, endued with Almighty power, and to will with infinite wiſdom, are the adorable perfections of the firſt cauſe.

The univerſe is undoubtedly derived from this cauſe. In vain do we endeavour by other means to account for it. We may every where obſerve order and ends; the effects of an eternal ſelf-exiſtent reaſon.

2. What mind can fathom the depths of this abyſs? What thought can comprehend that power which calls things that are not as though they were? God commands the univerſe to be; the univerſe is inſtantly produced.

A ſingle act of his will produced the univerſe; the ſame act preſerves it.

But you aſk, why is not man as perfect as an angel? You mean to ſay, no doubt, why is not man an angel? You may as well inquire, why a ſtag is not a man? But the exiſtence of a ſtag ſuppoſes that of herbs to nouriſh him. Would you ſtill further have had theſe herbs to have been ſo many men? Their preſervation and increaſe would have depended on the earth, the water, the air, and the fire: would you preſume to inſiſt in your inquiry, why the conſtituent parts of theſe elements were not ſo many dwarfs?

Confeſs your error, and acknowledge that every being is endued with a perfection ſuited to the ends of its creation. It would ceaſe to anſwer that end, the very moment it ceaſed to be what it is. By changing its nature, it would change its place, and that which it occupied

occupied in the univerſal hierarchy ought ſtill to be the reſidence of a being reſembling it, otherwiſe harmony would be deſtroyed.

In the aſſemblage of all the orders of relative perfections, conſiſt the abſolute perfection of this whole, concerning which God ſaid, that it was good.

This immenſe ſyſtem of co-exiſtent and ſucceſſive beings, is no leſs one in ſucceſſion than in co-ordination: ſince the firſt link is connected with the laſt by the intermediate ones. Preſent events make way for the moſt diſtant ones. The germ which expanded itſelf in Sarah's womb, was the preparatory cauſe of the exiſtence of a great people and the ſalvation of nations.

3. The heavens declare the glory of God, and the firmament ſheweth his handy-work. That ſublime genius, who expreſſed himſelf with ſuch loftineſs of ſentiment, was nevertheleſs unapprized that the ſtars which he contemplated were in reality ſuns.* He anticipated the times, and firſt ſung that majeſtic hymn, which future and more enlightened ages ſhould chaunt forth to the praiſe of the founder of worlds.

This aſſemblage of vaſt bodies is divided into different ſyſtems, the number of which perhaps exceeds the grains of ſand, which the ſea caſts on its ſhores.

Each ſyſtem then has its centre, either a ſtar or ſun, which ſhines with its own light, and round which revolve various orders of opake globes, that reflect with greater or leſs luſtre the light they borrow from it, which renders them viſible to us.

Theſe globes which ſeem to wander among the heavenly bodies, are thoſe planets, the principal of which have the ſun for the common centre of their periodical revolutions; whilſt the others, which are called ſecondary move round one principal planet, which they accompany like ſatellites, in its annual revolution.

Venus and the earth have each of them their ſatellite.

* Perhaps ſo.

One

One will undoubtedly be ſome time or other diſcover, ed in mars. Jupiter has four, ſaturn five, and a ring- or luminous atmoſphere which ſeems to perform the office of a number of ſmall moons: being ſituate ſo far from the ſun, he would have received too faint a light from it, if his ſatellite and ring did not augment it by reflection.

We have diſcovered twenty-ſeven planets, which at preſent compoſe our ſolar ſyſtem; but we are not certain that there are not more. Their number has received a great increaſe by the invention of teleſcopes: more perfect inſtruments, and more accurate obſervers, may probably make farther additions to them. The ſatellite of venus diſcovered in the laſt century gives room to hope for ſtill greater ſucceſs.

4. The comets alſo are now found to be planetary bodies, whoſe long routes our aſtronomers calculate, foretel their diſtant returns, and determine their place, appearances, and tract. Upwards of thirty of theſe bodies at preſent acknowledge the empire of our ſun, and the orbits which ſome trace round are ſo extenſive, that they do not complete their courſe till the end of a long ſeries of years, and even many ages.

The ſtars are innumerable; and the conſtellations, which antiquity reckoned to be but few in number, amount to thouſands.

If the diameter of the great orbit which our planet deſcribes round the ſun, is more than ſixty millions of leagues, yet this vaſt circumference vaniſhes into nothing, and become a mere point, when made uſe of to meaſure the diſtance of the fixed ſtars.

How great then muſt the real bulk of theſe luminous ſpots be, that are perceivable by us at ſuch enormous diſtance! The ſun is ſuppoſed about a million of times greater than the earth, and a hundred and ten times greater than all the planets put together.

5. Whilſt the planets perform theſe revolutions round

round the ſun, by which the courſe of their years is regulated, they effect another among themſelves, which determines the alternatives of their days and nights.

But how do theſe vaſt bodies remain ſuſpended in ſpace? What ſecret power retains them in their orbits, and enables them to circulate with ſo much regularity and harmony? Gravity, that powerful agent, is the univerſal principle of this equilibrium and theſe motions. It penetrates into the inmoſt parts of all bodies. By virtue of this force they tend towards each other in a proportion relative to their diſtance and bulk. So that the planets tend towards the common centre of the ſyſtem, and they would be inſtantly precipated into it, if the Creator, when he formed them, had not endued them with a centrifugal motion, by which they are continually kept at a due diſtance from the centre. Each planet, in conſtant ſubſerviency to theſe two forces, deſcribes a curve in conſequence thereof. By this means the ſame force which determines the fall of a ſtone, is the ruling principle of the heavenly motions: wonderful mechaniſm! whoſe ſimplicity and energy give us unceaſing tokens of the profound wiſdom of its author.

The globe of earth, which is externally divided into lands and ſeas, nearly level in their ſurfaces, is formed within, at leaſt to a certain depth, of beds of heterogeneous matter, that are almoſt parallel, more or leſs denſe, and of a finer or coarſer texture.

The ſurface of the earth abounds with great inequalities. In one part of it we behold vaſt plains interſected by hills and vallies. In another long chains of mountains, which lift their frozen heads to the clouds; and betwixt them deep vallies. From the boſom of theſe mountains rivers ſpring, which after having watered divers countries, and produced ponds and lakes in ſeveral places by enlarging their beds, at length diſcharge themſelves into the ſea, and reſtore to it what it had loſt by evaporation.

6. The

6. The ſea preſents us with iſlands ſcattered round its coaſts, with ſands, rocks, currents, gulphs, and ſtorms, and with that regular and admirable motion whereby its waters riſe and fall twice in twenty-four hours.

The lands and ſeas are every where repleniſhed with plants and animals, whoſe infinitely varied ſpecies reſort together in every place. Men divided into nations, peoples, and families, cover the ſurface of the globe. They faſhion and enrich it by their various labours, and build habitations from pole to pole, correſponding with their manners, genius, ſoil, climate.

A rare, tranſparent, elaſtic ſubſtance encompaſſes all parts of the earth to a certain height: this ſubſtance is the atmoſphere, the repoſitory for the winds, the immenſe reſervoir of vapours and exhalations, which being ſometimes collected into clouds of a greater or leſſer conſiſtence, adorn our element by their forms and colours, or aſtoniſh us by their flaſhes and violent noiſe; and at other times melting into dews, miſts, rain, ſnow, hail, yield back to the earth what was exhaled from it.

7. The moon, the neareſt to the earth of all the planets, is that we have the beſt knowledge of. Its globe, which is about five and forty times leſs than ours, always appears to us with the ſame aſpect, becauſe it performs its revolution preciſely in the ſame ſpace of time that it revolves round the earth.

It has its gradual and periodical increaſe and decreaſe of light, according to its poſition with reſpect to the ſun which enlightens it, and to the earth whereon it reflects the light of that ſun.

The diſk of the moon is externally divided into luminous and obſcure parts. The former ſeems analogous to lands on our globe, and the latter to our ſeas.

In the luminous parts there have been obſerved ſome places

places brighter than the reſt, which caſt a ſhade from their ſide, which has been meaſured, and the tract aſcertained. Theſe parts are mountains much higher than ours, in proportion to the ſize of the moon, and whoſe tops the ſun has been ſeen to gild when that planet is quartered; the light deſcending by little and little to the foot of theſe mountains, they appear at that time entirely bright. Some are by themſelves, others form very long tracts.

Venus has, like the moon, her ſpots, and mountains. So have mars and jupiter. Thoſe in jupiter form large belts, which make conſiderable motions, like the oceans overflowing the lands, and afterwards leaving them dry on his retreat.

Mercury and ſaturn are little known to us; the firſt, becauſe it is too near the ſun, the ſecond becauſe it is at too great a diſtance.

Laſtly, the ſun itſelf has ſpots, which ſeem to move regularly, and whoſe ſize equals, and very often exceeds that of ſuch as are ſeen in the greateſt planets.

8. Pure ſpirits, immaterial and intelligent ſubſtances: extenſive and ſolid ſubſtances: mixed beings, formed by the union of an immaterial ſubſtance and a corporeal; are the three general claſſes of beings which we have any conception of in the univerſe.

In the univerſe all is combination, affinity, connexion. There is nothing but what is the immediate effect of ſomewhat preceding it, and determines the exiſtence of ſomething that ſhould follow it.

The divine mind has ſo cloſely connected every part of his work, that there is not one which has not a relation to the whole ſyſtem. A muſhroom, a mite, are as eſſential parts of it as the cedar or elephant.

So that thoſe minute productions of nature which unthinking men judge to be uſeleſs, are not mere particles

ticles of duſt on the wheels of the machine of the world; they are ſmall wheels intermixed with the greater.

There is nothing then by itſelf. Every being has an activity peculiar to it, determined by the rank appointed for it in the univerſe. A mite is a very ſmall moveable creature, which acts in concert with others, whoſe activity extends to much greater diſtances. The ſpheres thus enlarging themſelves more and more, this amazing progreſſion riſes by degrees from the vortex of amber to the ſolar vortex; from the ſphere of a mite to that of an angel.

9. The elements act reciprocally on each other, according to certain laws which reſult from their relations; and theſe relations unite them to minerals, plants, animals, and to men. This laſt, as the principal trunk, ſpreads its branches all over the globe.

Theſe ſpecies and individuals have relation to the bigneſs and ſolidity of the earth. The ſolidity and ſize of the earth have relation to the place ſhe occupies in the planetary ſyſtem.

The ſun gravitates on the planets; the planets on the ſun, and on each other. All gravitate on their neighbouring ſyſtems; theſe on more diſtant ones; and the balance of the univerſe remains in equilibrio, in the hands of the antient of days.

The human ſoul, by being united to an organized body, maintains an intercourſe with all nature.

From theſe general principles proceeds the connection of cauſes and effects, of effects and cauſes.

From hence alſo ariſes that indiſſoluble union which forms, of paſt, preſent, future, and eternity, one entire individual whole.

The beauty of the world is founded in the harmonious diverſity of the beings that compoſe it, in the number, extent, and quality of their effects, and in the degree of goodneſs ariſing therefrom.

CHAP.

CHAP. II.

Of the relative Perfection of Beings.

I. TERRESTRIAL beings may naturally be ranged under four general claſſes:

I. Brute and inorganized Beings.
II. Organized and inanimate Beings.
III. Organized and animate Beings.
IV. Organized, animate, and reaſonable Beings.

All beings are perfect, conſidered in themſelves; they all anſwer one end. The determinations or qualities proper for each being, are the means relative to this end. If theſe determinations ſhould change, they would no longer have a reference to their end, and there would be no more wiſdom.

But thoſe means which are of a more exalted nature anſwer a nobler end. The being appointed to fulfil this end, is enriched with proportionable faculties.

Beings whoſe relations to the whole are more varied, more multiplied, and more copious, poſſeſs a higher degree of relative perfection.

As there are two general claſſes of ſubſtances, bodies and ſouls, there are likewiſe two general claſſes of perfection, the corporeal perfection, or that which is peculiar to bodies: and the ſpiritual perfection, or that which is peculiar to ſouls.

Theſe two perfections are re-united in every organized, animated being, and they correſpond with one another.

From their re-union proceeds that mixed perfection which

which anſwers to the rank every being holds in the ſyſtem.

2. Of all the modifications of matter, the moſt excellent is organization.

The moſt perfect organization is that which produces moſt effects, with an equal or ſmaller number of diſſimilar parts. Such amongſt terreſtrial beings is the human body.

An organ is a ſyſtem of ſolids, whoſe ſtructure, arrangement, and action, have motion for their ultimate end, either inteſtine or loco-motive, or feeling.

A being, which is barely formed by a repetition of ſimilar parts, enjoys the loweſt degrees of corporeal perfection. Such probably is the atom or elementary particle.

The faculty of generalizing ideas, or abſtracting from a ſubject what it has in common with others, and expreſſing it by arbitrary ſigns, conſtitutes the higheſt degree of ſpiritual perfection; and therein conſiſts the difference between the human ſoul and the ſoul of brutes.

The ſoul which is only endued with ſenſe occupies the loweſt degree in the ſcale. This perhaps is the perfection of the ſoul of the muſcle.

3. The reciprocal action of ſolids and fluids is the foundation of the terreſtrial life.

To nouriſh ourſelves, to grow by our food, to beget individuals of our own ſpecies, are the principal ends of the terreſtrial life.

If the action of the organs is not accompanied with a ſenſe of this action, the organized being enjoys only a vegetative life. Such is the caſe of the plant.

If the action of the organs is joined with a ſenſe of that action, the organized being enjoys a vegetative and ſenſitive life. This is the condition of the brute.

Finally, if reflection is joined to feeling, the being enjoys at the ſame time a vegetative, ſenſitive and reflective

flective life. It is man alone, upon earth, that unites theſe three kinds of life in himſelf.

The corporeal and intellectual faculties may be carried to ſo high a pitch of perfection, in the moſt exalted order of mixed beings, that we are able to form but faint ideas of them.

4. Between the loweſt and higheſt degree of corporeal and ſpiritual perfection, there is an almoſt infinite number of intermediate degrees. The reſult of theſe degrees compoſes the univerſal chain. This unites all being, connects all worlds, comprehends all the ſpheres. One ſole being is out of this chain, and that is he that made it.

A thick cloud conceals from our ſight the nobleſt parts of this immenſe chain, and admits us only to a ſlight view of ſome ill-connected links, which are broken, and greatly differing from the natural order.

We behold its winding courſe on the ſurface of our globe, ſee it pierce into its entrails, penetrate into the abyſs of the ſea, dart itſelf into the atmoſphere, ſink far into the celeſtial ſpaces, where we are only able to deſcry it by the flaſhes of fire it emits hither and thither.

But notwithſtanding our knowledge of the chain of beings is ſo very imperfect, it is ſufficient at leaſt to inſpire us with the moſt exalted ideas of that amazing and noble progreſſion and variety which reign in the univerſe.

5. There are no ſudden changes in nature; all is gradual, and elegantly varied. There is no being which has not either above or beneath it ſome that reſemble it in certain characters, and differ from it in others.

Amongſt theſe characters which diſtinguiſh beings, we diſcover ſome that are more or leſs general. Whence we derive our diſtributions into claſſes, genera, and ſpecies. But there are always between two claſſes, and two like genera, mean productions, which ſeem

not

not to belong more to one than to the other, but to connect them both.

The polypus links the vegetable to the animal. The flying ſquirrel unites the birds to the quadruped. The ape bears affinity to the quadruped and the man.

But if there is nothing cut off in nature, it is evident that the diſtributions we make are not her's. Thoſe we form are purely nominal, relative to our neceſſities and the bounds of our knowledge. Thoſe intelligences which are ſuperior to us, diſcover perhaps more varieties between two individuals which we range under the ſame ſpecies, than we do between two individuals of diſtant genera.

So that theſe intelligences ſee the ſcale of beings all compoſing one ſingle conſequence, which has for its firſt term an atom, and for its laſt the moſt exalted ſeraph.

We may then ſuppoſe in the ſcale of our globe as many ſteps as we know there are ſpecies. The eighteen or twenty thouſand ſpecies of plants which compoſe our herbals, are therefore eighteen or twenty thouſand ſteps of this celeſtial ladder.

And there is not a ſingle plant amongſt theſe, which does not perhaps nouriſh one or more ſpecies of animals. Theſe animals harbour or provide nouriſhment for others in their turn. They are ſo many little worlds comprized in others that are ſtill ſmaller.

Simple produces compound. The molecule forms the fibre, the fibre the veſſel, the veſſel the organ, the organ the body.

The ſcale of nature then is conſtructed by paſſing from that which compoſes it, to that which is compoſed by it, from the leſs perfect to the greater.

But while we view it in this light, and in a very general manner, we are not to forget that our method of conception is not the rule of things. We are only to take a tranſient ſurvey of the exterior parts of beings.

CHAP.

CHAP. III.

A general View of the gradual Progression of Beings.

1. FROM the immutability of ſpecies amidſt the perpetual motion that reigns in the univerſe, is deduced the indiviſibility of the firſt principle of bodies: and the indiviſibility of theſe principles would demonſtrate the ſimplicity of their nature, if God had not power to render the highly compounded particles incapable of ſeparation.

The nature of elementary atoms, their forms, relative proportions, and the manner whereby they effect the formation of bodies, are branches of knowledge that ſurpaſs the reach of the human mind.

So that we cannot determine whether there are as many ſpecies of elements as of bodies; or whether the ſame elementary particles, variouſly combined, give birth to different compounded ſpecies.

We are likewiſe ignorant what it is that eſſentially diſtinguiſhes one body from every other; thoſe we call eſſential characters, are only the ultimate reſult of the firſt principles.

O how intereſting would the ſight be, were we permitted to penetrate into theſe principles! A new world would diſcloſe itſelf to our view; nature then become tranſparent, would no longer conceal her way from us: her laboratories and workſhops would then be thrown open. Here we ſhould ſee her collecting the principles of metals; there behold her preparing the colour

colour of the roſe. Farther, we might trace her footſteps into the wonders of light and electricity. In other places ſhould obſerve her ſketching the out-lines of a plant or animal. Aſtoniſhed at the ſight of this admirable work we ſhould never be weary of contemplating the infinite diverſity of preparations, combinations, and motions, by which it is inſenſibly brought to its perfection.

Ye celeſtial ſpirits who aſſiſted at the creation of our world, you enjoy theſe pleaſures! Being more favoured than us by the maſter of nature, you penetrate into what eſcapes our notice, and ſee with what difficulty we creep from one truth to another, as we obſerve the efforts of an ape to imitate a man.

2. Obſerve three principal kinds of compoſitions in terreſtrial bodies. 1. That of fluids. 2. That of rude or in-organized ſolids. 3. That of organized ſolids.

The firſt genus, which is the moſt ſimple, ſeems to conſiſt in a bare contact of homogenous particles, which tend towards each other; but the leaſt force divides them.

The ſecond, which is more compounded, is formed of the union of different particles into a ſolid maſs.

The third, ſtill more compounded, is formed of the intermixture of an infinite number of parts, ſome fluid, and others ſolid.

3. The ſmall reſiſtance which fluids make to the force that divides them, their inclination to a level, the quickneſs and eaſe wherewith they move, penetrate, and ſeparate ſolids, ſerve to indicate that they are of all bodies the moſt ſimple, ſubtle and active.

Fire ſeems to be a fluid which unites theſe qualities in the moſt eminent degree. It is evident from a number of experiments, and particularly from thoſe made by electricity, that fire is a fluid diffuſed into all bodies, in various proportions. Sometimes it barely fills their

their pores: at others, is intimately united to their conſtituent parts, and compoſes inflammatory matter.

Air and water are likewiſe contained in the compoſition of a prodigious number of matters of different kinds. Sometimes they ſeem to change their nature, and to undergo various transformations; but theſe transformations are only imaginary. They reſume their primitive ſtate, as ſoon as the cauſes which obſcured them ceaſe to act.

4. Pure earth is the baſe or foundation in the compoſition of ſolids. The chymiſt meets with it in every body he analyſes. Being fixed and unalterable, it will reſiſt the moſt violent fire; and this immutability of elementary earth, by convincing us of the ſimplicity of its nature, ſhews likewiſe that it is the firſt ſtep of the ſcale of inactive ſolids.

From a mixture of pure earth with oils, ſulphurs, ſalts, &c. proceed the various ſpecies of more or leſs compounded earths, which are the proper nouriſhment of one part of organized bodies.

Bitumens and ſulphurs, which are chiefly formed of inflammable matter and earth, ſeem to lead us from pure earth to metallic ſubſtances, in which we diſcover the ſame eſſential principles, only differently combined.

The inalterability of gold from the moſt violent fire, its malleability, and prodigious ductility, equally prove the homogeneouſneſs, extreme fineneſs, and ſtrict union of its parts.

Other metals are ranged after gold, according to the order of their compoſition, or the ſtronger or weaker combination of their principles. Platina immediately follows gold: and ſilver that. Silver alſo reſiſts the action of fire; but is leſs malleable and ductile than gold, and diſſoluble by a much greater number of diſſolvents.

Copper appears after ſilver, and has a great affinity to that metal. It is itſelf ſucceeded by tin, lead, and iron.

Thoſe

Thoſe compounds which differ from metals only by their not being malleable, bear a great reſemblance to them, and are called demi-metals. Such are antimony, biſmuth, ſpelter.

Vitriols, produced by the union of metallic particles with a coagulated acid, ſeem, to be the paſſage from metallic ſubſtances to ſalts.

Salts, which always affect determinate and conſtant figures, indicate thereby the invariableneſs and ſimplicity of their principles, whoſe fundamentals are water and earth.

When they are diſſolved by water, or volatilized by air, they become one of the principal cauſes of the growth of vegetables, as they are of fermentations, whoſe effects are ſo various and extenſive.

The regularity and uniformity of the different kinds of cryſtallization, ſufficiently prove that they are to be attributed to ſalts, which being diſſolved and conveyed by a liquid, and united to foreign matters, compoſe theſe pyramidal maſſes.

Stones, whoſe ſpecies are ſo numerous, preſent us with maſſes of every form, colour, ſize, and conſiſtence, according to the diverſity of liquids, earth, ſulphur, metallic parts, ſalts, places, and other circumſtances which contributed to their formation.

Some of them are perfectly tranſparent, and theſe ſeem to be the moſt ſimple. Others are more or leſs opaque, as their principles are more or leſs heterogeneous, or more or leſs mixed.

5. The apparent organization of leafed ſtones, or ſuch as are divided into layers, as ſlates, that of fibrous ſtones, or thoſe compoſed of filaments, as the amianthus, ſeem to conſtitute the paſſage from rough to organized ſolids.

We muſt however allow, that this tranſition is not ſo happily effected, as thoſe we obſerve in divers other claſſes of terreſtrial beings.

Organized ſolids are divided into two general claſſes; vegetable and animal.

It is not eaſy to detrmine preciſely the diſtinction between theſe two claſſes. We cannot clearly diſcern

where the vegetable terminates, or the animal commences.

Neither the greater or leſs degree of ſimplicity in organization, nor the method of production, nouriſhing, increaſing and multiplying, nor the locomotive faculty, ſufficiently enables us to diſtinguiſh between theſe two orders of beings.

There are ſome animals whoſe ſtructure appears as ſimple as that of plants.

What the ſeed and germ are to the plant, the egg and embryo are to the animal.

The plant and animal increaſe in equal proportion by an inſenſible expanſion occaſioned by nutrition.

The matter received in both of them by inward ſuſception, is there ſubject to analogous preparations. One part ſerves as a clothing to the eſſence of the plant or animal; the reſt is evacuated.

There is in plants as well as animals a diſtinction of ſexes; and this diſtinction in them is followed by the ſame eſſential effects that accompany the latter. Several kinds of animals multiply by ſlips and ſprigs; and there are ſome, that, like plants, paſs their whole lives without changing their ſituation.

If there is any one character, peculiar to the animal, it is that of being furniſhed with nerves.

6. The plant which ſeems to occupy the loweſt place in the ſcale of vegetables, is a ſmall unformed maſs in which the eye can only perceive a kind of marbling, without any diſtinct part. This plant is the truffle, the ſeeds of whieh are diſcovered by the microſcope.

At a ſmall diſtance from theſe, is the numerous family of muſhrooms and agarics, which would be taken for different kinds of excreſcences, were it not that the eye, by the aſſiſtance of a glaſs, can diſcover flower and ſeeds in their folds or cavities.

Liverworts, equal in the number of their ſpecies to muſhrooms,

muſhrooms, nearly reſemble them. They cleave to the ſurface of ſtones, dry wood, trees, &c. ſometimes like brown ſpots, at others in pieces of a circular form, of a grey, or yellow colour, compoſed of ſmall ſhells or nobs, or notched like fringe, lace, &c. The ſeeds are contained in ſmall capſules, inviſible to the naked eye, as are likewiſe the flowers.

Moſſes ſeem to be a ſpecies between the muſhrooms and liverworts. They delight in ſhade and moiſture, and cling to various ſorts of bodies. The filaments which iſſue from them are often of a cotton-like nature, and bear flower and ſeeds.

7. Plants are of three very diſtinct ſorts.

The firſt, which are for the moſt part of a ſmall ſize, delicate conſtitution, inactive, and abounding in humours, live but a ſhort time; a year is commonly the term of their life.

The ſecond, which are for the moſt part of a gigantic ſize, robuſt conſtitution, hard, and not ſo full of humours, live many years, and even for ſeveral ages.

The third bear a mean proportion between the firſt and ſecond.

Herbs are the firſt, trees the ſecond, ſhrubs the third.

Theſe three kinds which are ſpread over the face of the earth, live promiſcuouſly therein; but there exiſts in the different claſſes, an almoſt infinite diverſity of ſizes, forms, colours, and inclinations.

They all in common paſs their lives in a ſtate of immoveableneſs. Fixed to the earth by various ſorts of fibres, they derive their principal nouriſhment from it, and with them to live is to expand themſelves.

8. The roots, ſtalk, branches, leaves, flowers, and fruits, comprize all that is moſt remarkable in the external parts of plants.

The roots, by means of their different kinds of hinges, tuberoſities, and ramifications, keep the plant fixed to the earth, while their pores imbibe an exceed-

ing fine ſlime, which the water liquefies, and carries with it.

From the root ſprings the ſtalk, to which the plant partly owes its ſtrength and beauty. Being ſometimes ſhaped like a pipe, it is fortified with knots ſkilfully diſpoſed. As it is ſometimes too weak to ſupport itſelf, it contrives means to twiſt itſelf about a ſolid prop, or to faſten to it by means of the little hands it is furniſhed with. Otherwiſe it appears a ſtrong pillar, bears its proud head aloft in the air, and braves the efforts of ſtorms and tempeſts.

The branches ſhoot forth, like ſo many arms, from the trunk and ſtalk, on which they are diſtributed with great regularity. They are divided and ſub-divided into many ſmall boughs, and the ſub-diviſions obſerve the ſame order as the principal diviſions.

The leaves, that charming ornament of plants, are diſpoſed round the ſtalk and branches with the ſame ſymmetry. Some are ſimple, others compounded, or formed of various foliage. One ſort is plain; another indented. Some of them are very thin, others hard, ſoft, plump, ſmooth, rough, or hairy.

The flowers, whoſe enamel is one of the principal beauties of nature, are not leſs diverſified than the leaves. Some have only a ſingle leaf, others ſeveral. Here it appears like a large veſſel opening itſelf gracefully; there it forms a groteſque figure in imitation of a muzzle, head piece or cowl. Farther ſtill, it is a butterfly, a ſtar, a crown, a radiant ſun. Some are diſperſed on the plant without any art; others compoſe noſegays, globes, tufts of feathers, garlands, pyramids.

The greater part of them are furniſhed with one or more cups, ſometimes ſimple and plain, at others conſiſting of ſeveral pieces.

From the centre of the flower proceeds one or ſeveral little pillars, either ſmooth or channelled, rounded at top, or terminating in a point, called piſtils, which commonly encompaſs other ſmaller pillars called ſtamina.

na. Theſe carry on the upper part of them a ſort of ſmall bladders full of exceeding fine powder, every grain of which, viewed through a microſcope, appears of a very regular figure, but varied, according to his ſpecies. In ſome they are ſmall, ſmooth globes; in others, they are thick ſet with prickles like the covering of a chefnut, and ſometimes they reſemble ſmall priſms, or ſome other regular body.

But how ſhall we expreſs their fineneſs, the lively appearance, delicacy, and variety of ſhadowings, which accompany, in many ſpecies of flowers, the ſweetneſs and agreeableneſs of the perfume?

The flowers are ſucceeded by the fruits and ſeeds. Magnificent decoration! Precious riches, which repair the loſſes occaſioned to plants by the intemperateneſs of ſeaſons, and the neceſſities of men and other animals.

All fruits and ſeeds have this in common, they encloſe under one or more coverings the germ of the future plants. Some have only ſuch coverings as immediately infold the germ, whoſe outſide is of the ſtrongeſt contexture; and among theſe, there are ſome that are provided with wings, tufts, or plumes of feathers, by means of which they are conveyed in the air or water, by which they are tranſported and ſown in different parts. Others are better clothed, being lodged in ſheaths or pods, encloſed in a kind of box, having one or more partitions. A third ſort, under a moſt delicious fruit, which is rendered ſtill more agreeable by its beautiful colour, contain a ſtone or kernel. Others are encloſed in ſhells which are either armed with prickles, abound with a bitter juice or adorned with fine hair.

The outſide of fruits and ſeeds do not afford leſs variety than the leaves and flowers; there is hardly any figure whatever which they do not furniſh a repreſentation of.

9. The inſide of plants is compoſed of four orders of veſſels, viz. the ligneous fibres, utriculi, or little bags,

bags, the proper vaſes, and the trachea or air-veſſels.

The ligneous fibres are very ſmall channels depoſited according to the length of the plant, and conſiſt of little pipes placed near each other. Sometimes theſe veſſels are parallel, and at others are ſeparated, leaving between them intervals or oblong ſpaces.

Theſe ſpaces are filled by the utriculi, a kind of membranous bladders, horizontally diſpoſed, and which communicate with each other.

The proper vaſes are a kind of ligneous fibres which principally differ from the reſt by their juice, which is of a deeper colour, or thicker.

In the middle of them, or round a great number of ligneous fibres, are ſome veſſels which are not ſo narrow, compoſed of a ſilvery elaſtic blade, formed ſpirewiſe, like a ſpring; theſe are arteries. They ſeldom contain any thing but air.

Theſe four orders of veſſels, which are diſperſed through all the parts of the vegetable, in proportion to the functions of each, compoſe, at leaſt in trees and ſhrubs, three principal beds, the bark, the wood, and the pith.

The bark, or rind, which is the outer covering of plants, and is ſmooth, even, and ſhining in ſome, and rough, channelled, and hairy in others, is formed of the wideſt fibres that are the leaſt preſſed together, and which admit within them the moſt air.

The wood, which is placed under the rind, has narrower and more contracted pipes, its utricles leſs repleniſhed or dilated: and this only has arteries.

The pith, which is ſituated at the heart of the plant, is little more than a collection of utricles, which are greater and more capacious than thoſe of the bark and wood.

wood. They diminiſh, and dry up, as the plant advances in age.

The ſimplicity of the organization of vegetables is the principal ſource of their different methods of multiplication.

A plant puſhes out buds from all points of its ſurface, theſe buds themſelves are plants: being cut, and laid in the ground, they take root there, and become entire plants, like that of which they were before only a part.

The ſmalleſt branch or leaf may give birth to ſuch a whole plant.

Suckers taken from different plants, and ingrafted in the ſtalk or branches of another plant, incorporate themſelves with it, and being united thereto, form one organical body.

10. The timorous ſenſitive plants flies the hand that approaches her; ſhe cloſes herſelf again with the utmoſt ſpeed; and this motion bearing ſo great a reſemblance to that of animals, ſeems to conſtitute one of thoſe connections whereby the vegetable and animal kingdoms are united.

A little above the ſenſitive, in a kind of calix, at the bottom of the water, is a ſmall body, exactly reſembling a flower. It draws back and entirely diſappears when I offer to touch it. It comes out of the calix, and opens itſelf on my retiring to a diſtance from it.

While I was endeavouring in vain to account for this, I diſcovered by the ſide of it another body of the ſame form, but larger, and not lodged in an encloſure. It was ſupported by a ſmall ſtalk, whoſe lower extremity joined to a plant, whilſt the other, inclining towards the ground, was divided into ſeveral little branches.

I immediately believed it to be a paraſite plant; and

in order to be more fully convinced of it, I cut it in halfs between its two extremities.

It ſoon ſprouted out again, and appeared the ſame as before. I ſtood awhile to conſider it. I ſaw the little branches move, and extend themſelves to ſeveral inches in length. They are extremely fine, and ſpread themſelves on all ſides.

A little worm came and touched one of theſe branches: it preſently twiſted itſelf about the worm, and by contracting itſelf, brought it to the upper extremity of the ſtalk. There I perceived a ſmall aperture, which enlarged itſelf in order to receive the worm. It was received into a long cavity that encloſes the ſtalk: being there diſſolved and digeſted before my eyes; I afterwards ſaw the remainder go out again at the ſame opening.

The next moment, this ſingular production ſeparated itſelf from the plant, and began to walk. The branches after having performed the office of arms are likewiſe employed by it inſtead of legs.

After having made theſe obſervations, I could not help acknowledging, that what I took for a paraſite plant, was a real animal. I then took a view of the piece I had cut off from it, and perceived, to my ſurpriſe, that it had grown, and was become a complete one like the other.

But my ſurpriſe was greatly increaſed, when at the end of ſome weeks I found theſe animals were tranſformed into two ſmall very buſhy trees.

From the trunk, which I knew to be the body of the animal, ſprung ſeveral branches on all ſides of it; from theſe branches, ſmaller ones ſprouted forth, and from thoſe, ſmaller ſtill. They all move different ways, and ſtretch out their branches, while the trunk continues fixed to a prop. This ſurpriſing aſſemblage forms only one entire body; and the nouriſhment it receives by one of its parts, is ſucceſſively communicated to all the reſt. In ſhort, this collection of bodies divides itſelf; each piece ſeparates itſelf from the others, and lives diſtinctly from them.

Amazed at theſe wonders, I part one of theſe animals

mals length-wiſe, about the middle of the body, I am preſently in poſſeſſion of a monſter with two heads.

I repeat the operation a great many times on the ſame ſubject, and by this means I give birth to a hydra, more aſtoniſhing than that of Lerna.

I part ſeveral of theſe animals tranſverſely, and lay the ſeparated pieces end to end. They graft or unite themſelves to each other, and compoſe only one entire animal.

To this prodigy I find a new one ſucceed. I turn one of theſe inſects, as we do a glove, putting the outſide within, and vice verſa. He does not ſuffer the leaſt alteration from that: he lives, grows, and multiplies.

Theſe animals which multiply by ſlips and ſhoots, that we engraft and turn inſide out, are polypus's.

They are of very different ſpecies. Many of them never ſhift their place. Some divide themſelves length-wiſe, and thus make very pretty noſegays, whoſe flowers are in cluſters.

11. There is a wonderful variety in the conſtruction of animal machines. There are ſome whoſe number of parts is very ſmall; others on the contrary, are very much compounded. In ſome there are only two or three pieces alike; others exhibit to us a much greater number. In ſhort, the ſame parts are differently diſpoſed or combined in different machines.

The perfection of the machines in nature conſiſts, as in thoſe of art, in the number of parts, and diverſity of effects. That is accounted the moſt perfect, which with the ſmalleſt number of parts, produces the greateſt variety of effects.

But there is, with reſpect to ourſelves, a conſiderable difference between the natural and artificial machines; for whereas we may judge of theſe by an exact compariſon of their ſtrength and produce, we can only form our opinion of the others by their conſequences.

After this manner we are enabled to judge of the

perfection of the human body, from the diverſity and extent of the operations of man, rather than from an inſpection of his organs, of which we have only a partial view. And if corporeal perfection correſponds with ſpiritual, as there is reaſon to believe it does, man, as he is ſuperior to other animals by underſtanding, ſo he likewiſe is by organization. Whence we may infer, that thoſe animals whoſe ſtructure moſt nearly reſembles that of men, ought to be conſidered as the moſt elevated in the ſcale.

12. Of all animals that are known to us, the polypus is one whoſe ſtructure ſeems to be the moſt ſimple, and to come neareſt that of plants. This extraordinary animal ſeems to conſiſt altogether of ſtomach. His body and arms are compoſed of one and the ſame bowel, whoſe compoſition is perfectly uniform. The beſt microſcopes only diſcover in them an infinite number of ſmall grains, which are tinged with the nouriſhment the animal feeds upon.

Can theſe grains be ſo many utricles? Can they receive the aliment by immediate conduits, prepare it and tranſmit it to other veſſels appointed to convey it into the channels of circulation? Is there a circulation in the polypus?

The different kinds of veſſels which the firſt conjecture ſuppoſes, and which their fineneſs or tranſparency may render inviſible to us, muſt be lodged in the thick part of the texture of the polypus. We are induced to think ſo from the experiment of turning it inſide out, which being effected, does not cauſe any change in the vital functions.

But of what ſervice can that property be to the polypus, which it cannot make uſe of without the aſſiſtance of man? I mean the operation of turning the inſide outwards.

I anſwer, that this property is one of the conſequences of an organization peculiarly neceſſary to the polypus. The Author of nature never intended to create an animal capable of being turned as we do a glove:

glove: but he deſigned to form an animal whoſe principal viſcera were lodged in the thickeſt part of the ſkin, and which had power in a certain degree to eſcape various accidents to which the nature of its life unavoidably expoſed it. Now, what naturally follows from this organization is, the being enabled to endure this ſhifting without occaſioning its death.

13. Thoſe animals whoſe ſtructure appears leſs ſimple than that of the polypus, multiply like him by ſlips.

Theſe worms have a ſtomach, inteſtines, heart, arteries, veins, lungs, and organs of generation. If we look narrowly into the circulation of their blood, we ſhall perceive its continuance with the ſame regularity in all thoſe parts which have been ſeparated from the reſt by cutting.

Theſe worms bring us to treat of inſects.

14. Here we are introduced into a kingdom of animals, the moſt extenſive and diverſified of any on the ſurface of the globe. That province of this vaſt empire which is ſeen on the ſurface of vegetables, is ſufficient of itſelf to attract the curioſity of a traveller, either from the prodigious number of its inhabitants, or the ſingularity and diverſity of their forms.

Theſe are pigmies, the greateſt part of which are ſo minute, as not to be diſtinctly ſeen without the help of a microſcope. They bear the general name of inſects, and this name was given to them on account of the inciſions of various depths, by which the bodies of ſeveral of them are divided.

The character which ſeems eſſentially to diſtinguiſh inſects from other animals is, that they have no bones. The analogous parts with which ſome ſpecies of them are provided, are placed on the outſide of their bodies, whereas in other animals the bones are always on the inſide.

Life,

Life, in inſects, does not reſult from a mechaniſm as compounded, as in the animals of a larger ſize. In them, the number of different kinds of organs is ſmaller: but ſome of theſe organs ſeem more multiplied.

Conſidered in their exterior form, inſects may be divided into two claſſes. The firſt comprehends inſects improperly ſo called, whoſe body is continued; theſe bear the general name of worms. The ſecond claſs comprehends inſects properly ſo termed, whoſe body is divided by certain inciſions or contractions.

In the greater part of inſects of this claſs, the inciſions ſeparate the body into three principal parts, the head, the ſtomach, the belly: this diviſion has a relation to that obſerved in great animals. Some of the inſects of the firſt claſs are without legs: others are furniſhed with them. All the inſects of the ſecond claſs have legs; but ſome are winged, others not.

There is ſuch a diverſity in inſects, that it may be queſtioned if there is not united in them every variety to be met with throughout the animal world. And what renders this variety ſtill more ſurpriſing is, that it does not extend merely to the whole ſpecies, but likewiſe to individuals. The ſame inſect has at one time organs that are not to be found in him at another. The ſame individual which in his youth belonged to the firſt claſs, in a more advanced age takes up his rank in the ſecond. From thence ariſe the difficulties attending a proper diſtribution of theſe little animals.

15. The bodies of almoſt all inſects are formed of a collection of rings, ſet in each other, which by contracting or dilating, lengthening or ſhortening, contribute to all the motions of the animal.

The head, in many ſpecies changes its form in an inſtant. It contracts and dilates itſelf, lengthens and ſhortens, appears and diſappears, at the pleaſure of the inſect. The flexibility of its folds enables it to make theſe motions. In other ſpecies, the head is in one

one conſtant poſition, and bears a greater reſemblance to that of the larger animals, by the hardneſs of its covering, which is ſcaly.

The mouth is ſometimes diſcovered to be a ſimple circular aperture: but it is generally furniſhed with hooks, or a kind of pick-ax; with teeth, or two indented ſhells which they move horizontally; with a trunk, a very compact inſtrument, which ſerves to extract and liquefy, and raiſe up alimentary juice; or with a ſting, which is an organ analogous to the trunk, and endued with the ſame eſſential functions.

Several ſpecies have two of thoſe inſtruments united in them, ſometimes the teeth and the trunk, and ſometimes the trunk and the ſting. Many ſpecies of inſects are deprived of the uſe of ſight. With them the feeling or ſome other ſenſe, ſupplies the defect of eyes.

The eyes of inſects are of two kinds; the ſmooth ones are always few in number; the rough commonly amount to ſeveral thouſands, and are fixed on the ſides of the head, in the form of two ſemicircular maſſes. In both of them they are utterly immoveable; and their number compenſates in ſome meaſure the want of mobility: it is therefore leſs a mark of perfection than of imperfection. Many ſpecies have at the ſame time two ſmooth eyes and two rough ones.

Hearing ſeems to be denied to inſects: at leaſt the exiſtence of this ſenſe in them is very doubtful.

The caſe is not the ſame with reſpect to ſmelling. Divers inſects have it in an exquiſite manner, but the ſeat of it is not known. May it not be ſituate in thoſe two moveable horns called the antennæ, whoſe uſe we are yet unacquainted with?

The legs of inſects are ſcaly and membranous. Thoſe are moved by the aſſiſtance of divers articulations, while theſe, which are more pliable, are turned every way without difficulty. Theſe two ſorts of legs are often united in the ſame worm. Some of them have

ſeveral

ſeveral hundred legs; but do not on that account walk faſter than ſuch as have only ſix.

The wings, which are two or four in number, are ſometimes formed of a ſimple and more or leſs tranſparent gauze, and ſometimes covered with little ſcales differently figured; in ſome they are compoſed of feathers, as in birds, in others they are covered, or encloſed in caſes. In many ſpecies the male is winged, and the female not.

On the ſides or extremities of the body are little oval apertures, ſhaped like the ball of the eye, and ſuſceptible of the ſame motions. Theſe are ſo many mouths for the purpoſe of reſpiration.

16. The interior part of inſects contains four principal viſcera; the ſpinal marrow, the inteſtinal bag, the heart and the tracheal arteries.

A blakeiſh thread, which is extended the whole length of the belly from the head to the hinder part, and knit together at certain diſtances, is the ſpinal marrow of inſects, or the principal trunk of the nerves.

The knots placed from one ſpace to another, ſeem ſo many particular brains, appointed to diſtribute the nervous ſtrings to the neighbouring parts, from the action of which the feeling and motion proceed. The firſt of theſe knots conſtitutes the brain, properly ſo called.

On the medullary thread is placed the inteſtinal bag, which is equal to it in length. It is a long gut, in which are contained the æſophagus, the ſtomach, and inteſtines.

Along the back, and parallel to the inteſtinal bag, there runs a long and thin veſſel in which may be perceived, through the ſkin of the inſect, alternate contractions and dilatations. This is the heart, or that part which performs the functions of it.

The arterial veſſels of inſects perfectly reſemble thoſe of

of plants. There is in every part of them the ſame ſtructure, colour, elaſticity, deſtination, and diſperſion through the whole body.

17. Worms, whoſe bodies are lodged in a cruſtaceous or ſtony pipe, ſeem to conſtitute the connection between inſects and ſhell-fiſh.

There are notwithſtanding ſome ſhell animals, whoſe ſtructure with reſpect to its ſimplicity, ſeems to vie with that of the polypus.

Of this number is the pond muſcle, wherein we can diſcover neither ſpinal marrow, arteries, veins, or lungs.

Does the ſcale of nature branch out as it advances? May inſects and ſhell-fiſh be two parallel branches of this great ſtem? May the frog and the lizard, which bear ſo near a reſemblance to inſects, be a ramification of them? We are not able at preſent to anſwer theſe queſtions.

Such is the gradation between beings, that they often differ from each other by ſlender ſhadowings; and ſuch is the narrowneſs of our capacities, that none but the plain and more ſtriking marks attract our notice.

18. The agreeable diverſity in the figures of ſhells, helps us to judge of the variety ſubſiſting in the organization of thoſe animals who are the inhabitants and architects of them. Some conſiſt of one entire piece; others of two or more. Some are formed in imitation of a trumpet, a ſcrew, a tiara, a dial. Others reſemble a helmet, a club, a ſpider, a comb. In this, it is a kind of fleſhy caſe; in another it is a ſhip, wherein the ſailor is at the ſame time rudder, maſt, and ſail.

Animals that have ſhells, and inſects with ſcales, ſeem to have an affinity to each other by a common character; both of them have their bones placed on the outſide. We may in effect conſider the ſhell as the bone of the animal which occupies it; ſince he brings it into the world with him, and adheres to it by different muſcles.

But

But it is certain, moſt ſhells are formed of the ſtony juices, which tranſude from the pores of the animal.

The bones, as well as the ſhells of inſects, grow and are nouriſhed by veſſels which paſs through their ſubſtance.

Shell-fiſh form two great families, that of the conchæ, or larger kind, whoſe ſhell is made up of two or ſeveral pieces; and that of ſnails, whoſe ſhell conſiſts of one ſingle piece, turned for the moſt part ſpirally.

The ſtructure of the firſt ſeems much more ſimple than that of the laſt. The conchæ have neither head, horns, nor jaws; one can only obſerve in them air-vents, a mouth, an anus, and ſometimes a ſort of foot. The greateſt part of ſnails, on the contrary, have a head, horns, eyes, a mouth, an anus, and a foot. The round and fleſhy head is at the anterior and upper part of the animal. It contains a brain, compoſed of two little globes, whoſe apparatus is of ſuch a moveable nature, that it is transferred from the hinder to the fore part at the pleaſure of the ſnail. The horns, which are two or four in number, placed on the ſides of the head, are a kind of pipes, ſuſceptible of various motions, and which the animal can draw into his head by the help of a muſcle, which the Grand Obſerver has ordained to perform the functions of the optic nerve. In ſome ſpecies of ſnails the eyes are placed at the extremity of the horns, as at the end of the ſhank of a pair of ſpectacles. In others at the baſe, or towards the middle. They are black and brilliant, pretty much reſembling the form of a very ſmall onion. We can only diſcover their tunic, which is called the uvea; but they have the three humours belonging to our eye. The mouth, which is commonly a ſmall chink, like a furrow, is furniſhed in many ſpecies of them, with two cartilaginous jaws placed on each other, whoſe inequalities or clefts perform the office of teeth, ſome ſpecies have real teeth, like thoſe of a ſea-dog, which are extremely ſmall.

The ſhell-fiſh that have no jaws, have a fleſhy or muſcular pipe, which ſupplies the place of a ſnout.

Snails

Snails are not provided with feet; but they have one foot of a particular make, which is nothing more than a collection of a great number of muſcles, whoſe motions imitate thoſe of the waves of the ſea. A pretty thin membrane lines the inſide of the ſhell, and ſometimes the outſide. It is a kind of mantle, furniſhed with trachea or air-vents, which ſeparate the air from the water, at the origin of which are perceived little gills deſtined to the ſame uſes. The heart, which is ſituated near the ſurface of the body, has a ſenſible motion, whereby it riſes and falls alternately. In the conchæ it is underneath the ſtomach.

19. Animals with ſhells bear an affinity to fiſhes. Reptiles ſeem to take place between or next to them, being united to ſhelled animals by the ſlug, and to the fiſhes by the water-ſerpent.

In reptiles, animal perfection begins to increaſe in a ſenſible manner. The number of their organs, their conformation and exerciſe, give them on this account, a greater analogy with the mechaniſm of thoſe animals we eſteem the moſt perfect. The organs of viſion, hearing, and circulation, furniſh examples ſufficient to indicate this. This analogy is augmented in fiſhes.

The eel by its formation, and creeping fiſhes by their method of moving, connect fiſhes with the water-ſerpent.

20. Fiſh like reptiles are for the moſt part covered with ſcales, whoſe figure and rich colours help to make a diſtinction between the ſpecies.

There is a great variety in the form of fiſhes. Some are long and ſlender; others are broad and ſhort. We ſee among them flat, cylindrical, triangular, ſquare, and circular ones. Some are armed with a great horn. Others wear a long ſword, or a kind of ſaw. A third ſort are furniſhed with pipes, through which they throw out the remainder of the water they have ſwallowed. Wings are to birds of the ſame uſe as fins to fiſhes.

fiſhes. Some have two or three: others have a greater number. The head of fiſhes, like that of reptiles, is joined cloſe to the body. The mouth, which is commonly furniſhed with two or more rows of teeth, is ſometimes placed on the back, as are the eyes. The lungs which are formed of ſeveral blades or vaſcular leaves, are often placed at the ſurface of the body. They are known by the name of gills. But let us avoid anatomical deſcriptions, which would carry us too far. We ſhall now confine ourſelves to ſome of the principal varieties, and to the ſources of thoſe relations that are more ſtriking.

21. I ſee the flying fiſh dart itſelf into the air from the bottom of the water, having fins reſembling the wings of a bat. Herein it has an affinity to birds. But I ſee a great animal advancing towards the ſea-ſhore, having a head and fore-part like a lion, and the hind-part reſembling that of a fiſh. It has no ſcales: and is borne on two paws that have toes with fins to them. 'Tis called the ſea-lion. He is followed by the ſea-calf, and the hippopotamus or ſea-horſe, and by all in general of the cetaceous kind. The crocodile and tortoiſe preſent themſelves to my view in their turn; and I now find myſelf among quadrupeds. Without preſuming to account for the ways of nature, we will at preſent place birds between fiſhes and four-footed animals. In this order aquatic birds are ranged immediately under the flying fiſh. Amphibious birds, or ſuch as live both on land and in the water, will occupy the ſcale next in courſe, and by this means open a communication between the terreſtrial, aquatic, and aërial regions.

To this new manſion there is added a new decoration. To ſcales ſucceed feathers, which are cloſer compacted and more varied: a bill takes place of teeth: wings and feet are to them inſtead of fins: lungs formed within, and a different ſtructure, cauſe the gills to diſappear: a melodious ſong follows a profound ſilence. Between the cormorant and ſwallow, the partridge and vulture, the humming bird and oſtrich, the owl and peacock, the raven and nightingale,

gale, what a ſurpriſing variety is there of ſtructure, proportion, colour, and ſong!

22. Hairy birds having projecting ears, a mouth furniſhed with teeth, and whoſe body is carried on four paws armed with claws, are they birds in reality? Are quadrupeds, that fly by the aſſiſtance of great membranous wings, really ſuch? The bat and flying-ſquirrel are theſe ſtrange animals, which are ſo proper for eſtabliſhing the gradation that ſubſiſts between all the productions of nature. The oſtrich with the feet of a goat, which rather runs than flies, ſeems to be another link which unites birds to quadrupeds.

The claſs of quadrupeds is not inferior in variety to that of birds. Theſe are two perſpectives of a different taſte, but which have ſome analogous points of view. Carnivorous quadrupeds anſwer to birds of prey. Quadrupeds that live on herbs or ſeeds, anſwer to birds that feed on the ſame kind of aliment. The ſcreech-owl among birds is the ſame as the cat among four-footed animals. The beaver ſeems anſwerable to the duck. Quaprupeds may be divided into two principal claſſes. The firſt comprehends quadrupeds with a ſolid foot. The ſecond comprizes quadrupeds whoſe feet are furniſhed with claws or toes. Amongſt quadrupeds of the firſt claſs, from the ſtag to the hog, and thoſe of the ſecond, from the lion to the mouſe, what a diverſity of models, ſizes, and motions, do we obſerve!

By what degrees does nature raiſe herſelf up to man?

How will ſhe rectify this head that is always inclined towards the earth? How change theſe paws into flexible arms? What method will ſhe make uſe of to tranſform theſe crooked feet into ſupple and ſkilful hands? Or how will ſhe widen and extend this contracted ſtomach? In what manner will ſhe place the breaſts, and give them a roundneſs ſuitable to them?

The ape is this rough draught of man: this rude ſketch; an imperfect repreſentation, which nevertheleſs

leſs bears a reſemblance to him, and is the laſt creature that ſerves to diſplay the admirable progreſſion of the works of God!

CHAP. IV.

Continuation of the gradual Progreſſion of Beings.

1. THE relations which the plant bears to thoſe beings that ſurround it, and from whence it derives its ſubſiſtence, are purely corporeal, or comprehended entirely within the ſphere of the properties of bodies. The animal, which is more excellent, is allied to nature by other connections, and by ſuch as are of a more exalted kind. Like the plant, it vegetates: like her, it receives that nouriſhment from without, which promotes the growth of it; and, like her, it multiplies. But to thoſe different actions, are ſuperadded feeling, or the perception of what paſſes within him. This ſenſe of feeling is connected with ſeveral others, which are produced various ways, and they are all accompanied either with pleaſure or pain.

Agreeable ſenſations inform the animal of the relations which certain bodies have to its preſervation or welfare: diſagreeable or painful ſenſations advertiſe him of qualities which are hurtful. He is then the centre to which divers objects are directed: he draws near ſome, and keeps at a diſtance from others. The nerves, or that cluſter of ſmall fibres which extend themſelves from the brain to all parts, like ſmall cords, conſtitute the immediate organ of feeling.

2. Does

2. Does ſpiritual perfection always anſwer to corporeal in animals? If this be true, how comes it to paſs, that the ſimple oſtrich appears inferior in point of underſtanding to the lion piſmire, which is placed ſo much beneath it in reſpect to ſtructure?

Let us not miſtake. The marks of underſtanding exhibited to us in ſome inſects are ſurpriſing, inaſmuch as we do not expect to meet with them in thoſe animals we ſcarce think capable of feeling. Our imagination is warmed, and we aſcribe to thoſe inſects more genius than they really have.

On the contrary, we form high expectations from larger animals; ſo that we are very apt to degrade them, as ſoon as we perceive they fall beneath the idea we entertained of them. There are ſome however, whoſe mind does not diſplay itſelf by ſtriking marks, but by a great number of leſs ſenſible ones, which, being united, form a degree of underſtanding ſuperior to that of the moſt induſtrious inſect. Such, without doubt, would appear to be the caſe of the oſtrich, were ſhe better obſerved. We reproach her, with indifference towards her eggs. It is affirmed, that ſhe leaves the care of hatching them to the ſun. This reproach is turned into a commendation, with regard to the oſtriches of Senegal, ſince an exact obſerver has beſtowed on them the attention they require. In theſe ſcorching climates, the ſun ſufficiently heats in the day-time, an oſtrich's eggs that are hid in the ſand. The warmth of the mother would be then unneceſſary, or even hurtful to them: ſhe would keep the ſun from them, whoſe rays are more active and efficacious. But the nights in Senegal are very cool: and the eggs would be in danger of growing cold. Then the mother never fails to procure them heat, by ſitting upon them during that time.

At the Cape of Good Hope, where it is not ſo hot as at Senegal, the oſtrich ſits night and day, like other birds. The young ones peck in a few hours after they are hatched; but they are not able to walk till ſeveral days

days afterwards : the dam takes care to place near them ſuch food as is proper for them.

Laſtly, it is to be remarked, that there is a kind of ſociety among large animals. Their memory retains faithfully a certain number of ſigns and ſounds. Their ſoul is affected by a variety of perceptions : ſight and hearing alone furniſh an abundant ſource to them. Inſects afford us but very imperfect images of this. The lion piſmire is ignorant of every thing but the ſnare he has laid, and the prey he expects in conſequence of it. His eyes, which are motionleſs and unmeaning, differ widely from ours ; nor is he affected by any ſound.

3. Thoſe are undoubtedly the moſt perfect animals, whoſe ſphere of underſtanding extends to the greateſt number of objects. Theſe are various in their operations, can ſhift about, and compaſs their ends by different ways. The polypus only knows how to lengthen and contract his arms. The ſpider ſpreads a net with a geometrical regularity. The falcon and dog purſue their prey with ſagacity. The ape preſumes to imitate man.

Has God created as many ſpecies of ſouls as of animals ? Or is there only one ſpecies of ſoul in animals, differently modified according to the diverſity of organization ? This queſtion is abſolutely impenetrable by us. All we can ſay concerning it, is this : if God, who has always acted by the moſt ſimple means, has thought proper to vary the ſpiritual perfection of animals merely by organization, his wiſdom has ſo ordained it.

4. At the ſummit of the ſcale of our globe is placed man, the maſter-piece of the earthly creation.

Not to dwell on the excellent conſtruction of his body, let us conſider man as an intelligent being. Man is endued with reaſon ; he has ideas ; he compares theſe ideas together ; judges of their relations or oppoſitions ; and acts in conſequence of this judgment. He alone, of all animals, enjoys the gift of ſpeech ; he clothes his ideas with ſuch ſigns as he thinks proper ;

and

and by this admirable prerogative he forms a connection between them, which renders his imagination and memory an ineſtimable fund of knowledge. By this means man communicates his thoughts, and brings all his faculties to a ſtate of perfection: by this he attains to all arts and ſciences: and by means of this, all nature is ſubject to him.

Sometimes, with a ſtrong and harmonious voice, he celebrates, in a poem, the virtues of a hero. At others, by a ſtroke of the pencil, he changes a dull canvas into a charming perſpective. Here we ſee him, with the chiſſel and graver in his hand, animating the marble, and giving life to braſs. There, with the plummet and ſquare, erecting a magnificent palace. Now we behold him, by a microſcope of his own invention, diſcovering new worlds amidſt inviſible atoms, or penetrating the ſecret exerciſe and motion of a particular organ. At other times, by changing this microſcope into a teleſcope, he pierces into the heavens, and contemplates ſaturn and his moons. Returning home, he preſcribes laws to the celeſtial bodies, deſcribes their paths, meaſures the earth, and weighs the ſun. Afterwards he dives into the nature of beings, examines their relations, and the admirable harmony reſulting from them, and by an attentive view of their various perfections, he ſees an immenſe chain formed, comprehending the whole.

In another ſtation, man is occupied in ſuch arts as contribute to the ſupply of his neceſſities, or conveniences. His reaſon condeſcends to every thing. The earth, cultivated by his care, teems every year with new productions. Hemp and flax diveſt themſelves of their bark to furniſh him with clothing. The ſheep abandons for his uſe his rich fleece, and the ſilk-worm ſpins for him her precious woof. The yielding metal is moulded in his hands. The ſtone ſoftens in his fingers. The largeſt and ſtrongeſt trees fall at his feet, and receive from him a new being. All the animals are ſubject to his laws; even the fierceſt of them inſult not his crown with impunity. He makes ſome ſerve for food;

food; others he harneſſes to his chariot; and others he condemns to till his lands. Many of them he appoints to be his porters, hunters, guards, and muſicians. In ſhort, man plows his adventurous way acroſs the vaſt ocean, and by navigation unites the two extremities of the globe.

5. The excellence of human reaſon ſhines likewiſe with a new luſtre, from the eſtabliſhment of ſocieties. In them, virtue, honour, fear, and intereſt, variouſly employed or combined, prove the ſource of peace, happineſs, and order. All the individuals, being mutually interwoven together, move in a regular and harmonious manner. Under the ſanction of the laws, the king, prince, and magiſtrate, by exerciſing a lawful authority, promote virtue, ſuppreſs vice, and ſpread around them the happieſt effects of their adminiſtration. In ſociety, as in a pure and fertile climate, talents of different kinds ſpring up and unfold themſelves. From that, the mechanical and liberal arts flouriſh. Laſtly, ſociety perfects friendſhip, that faithful companion of life, which adminiſters conſolation in our ſufferings, and gives a reliſh to our pleaſures.

6. The laſt mark of the greatneſs of man, and of his high exaltation above other animals, is the commerce he has with his Creator by religion.

Wrapped in the thickeſt darkneſs, the reſt of the animal creation are ignorant of the hand that formed them. They enjoy an exiſtence, but cannot trace the Author of life. Man alone ſoars to God the principle, and proſtrate at the foot of the throne of the Almighty, adores with the profoundeſt veneration, and with the moſt lively gratitude, the ineffable goodneſs that created him.

In conſequence of thoſe eminent faculties wherewith man is enriched, God condeſcends to reveal himſelf to him, and to lead him as it were by the hand in the paths of happineſs. The various laws he has received from the ſupreme Wiſdom, are ſo many lights placed at proper diſtances, on his road, to guide him from time to eternity.

Enlightened by this celeſtial guide, man advances in the glorious race that is ſet before him, and ſeizes the crown of life, and adorns with it his immortal brow.

7. Such is man in the higheſt degree of earthly perfection. But mankind have their gradations, as well as the other productions of our globe. There is a prodigious number of continued links between the moſt perfect man and the ape.

If you take a ſurvey of all nations of the earth; if you conſider the inhabitants of the ſame kingdom, province, city, or town; nay, do but examine with attention the members of the ſame family, and you will imagine you ſee as many ſpecies of men as you diſcern individuals.

To the Lapland dwarf, let the giant of Madagaſcar ſucceed. Let the flat-faced African, with his black complexion and woolly hair, give place to the European, whoſe regular features are ſet off by the whiteneſs of his complexion and beauty of his hair. To the filthineſs of a Hottentot, oppoſe the neatneſs of a Dutchman. From the cruel Anthropophagite paſs to the humane Frenchman. Place the ſtupid Huron oppoſite the profound Engliſhman. Aſcend from the Scotch peaſant to the great Newton. Deſcend from the harmony of Handel to the ruſtic ſongs of the ſhepherd. Put in the ſame ſcale the lockſmith conſtructing a jack, and Vaucanſon forming his automatons. Reckon up the number of ſteps from the ſmith that cauſes the anvil to groan, to Reaumur anatomizing fire.

Do theſe varieties ariſe from any real difference there is between human ſouls, independently on the organization of the body?

We ſhall not think ſo, if we pay a due attention to health and ſickneſs, to conſtitution and manner of living, to climate, and education.

You may perceive what a multitude of conſequences

a mathematician derives from a very ſimple principle: place this ſame principle in the hands of a man of the lower claſs, it will remain barren, and not be productive of the ſmalleſt truth.

May not the number of juſt conſequences which different minds deduce from the ſame principle, ſerve as a foundation for conſtructing a pſychometer upon; and may we not preſume that one time or other we ſhall be enabled to meaſure ſpirits as we now do bodies?

But the ſcale of the creation does not terminate at man. Another univerſe commences there, whoſe extent, perhaps, compared to that of this, is as the ſpace of the ſolar vortex to the capacity of a nut.

There ſhine the celeſtial hierarchies, like glittering ſtars.

There from all parts the angels, archangels, ſeraphim, cherubim, thrones, virtues, principalities, dominions, powers, caſt forth their radiant beams.

In the centre of theſe auguſt ſpheres, ſhines glorioufly the ſun of righteouſneſs, the eaſt above, whence all the other ſtars borrow their light and ſplendor.

Ye planetary worlds! celeſtial hierarchies! you ſink into annihilation in the preſence of the Lord: your exiſtence is by him: he is that he is: he alone poſſeſſes the plenitude of being: you enjoy but the reflection of it. Your perfections are ſtreams; the infinitely perfect being is an ocean, an abyſs, which the cherubim preſume not to look into.

If we enjoy a very ſenſible pleaſure on ſeeing collected, in one place, the principal productions of nature, how great muſt the extaſy of celeſtial ſpirits be, when they ſurvey thoſe worlds which God has thick ſown in the vaſt expanſe, and when they contemplate the immenſity of his works!

O! the delightful employment thoſe ſuperior intelligences are exerciſed in, when they compare the different œconomies of theſe worlds, and weigh in the balance of reaſon each of theſe globes!

But all celeſtial intelligences, doubtleſs enjoy not

theſe advantages in the ſame degree. There may be ſome perhaps to whom is granted the knowledge of one world only: others may know ſeveral: others a much greater number.

How immenſe muſt that Mind be, which beholds with a ſingle glance the ſum of all beings, and which by fathoming the ſpirits of all orbs, diſcerns in an inſtant, and without confuſion, the reſult of all the ideas that have, do now, and will hereafter occupy them!

Ye inhabitants of the earth, who have received reaſon ſufficient to convince you of the exiſtence of theſe worlds, will you for ever be denied entrance into them? Will the infinitely good Being, who ſhews them to you at a diſtance, always refuſe you admittance into them? No; ſince you are called to reſide ere long among celeſtial hierarchies, you will like them fly from planet to planet: you will eternally advance from perfection to perfection, and every inſtant of your duration will be diſtinguiſhed by the acquiſition of farther degrees of knowledge. Whatever has been with-held from your terreſtrial perfection, you will obtain under this œconomy of glory: "you will know even as you are known."

"Man is ſown corruptible, he will riſe incorruptible and glorious:" theſe are the words of the apoſtle and philoſopher: the covering of the ſeed periſhes; the germ ſubſiſts, and aſſures man of immortality.

Man therefore is not in himſelf what he appears to be. What we diſcover of him here below is only the groſs foldage under which he crawls on the earth, and which he muſt ſhortly caſt off.

The brain is a ſmall organical machine, deſtined to receive the impreſſions made on the different parts of the body, and to tranſmit them to the ſoul. It is by means of this that the ſoul acts on various points of the body, and adheres to nature.

The extremities of all the nerves, radiate to the ſeat of the ſoul: it is in ſome meaſure the centre of this admirable collection, the threads of which are ſo numerous, fine, delicate, and full of motion.

But the nerves are not ſtretched like the ſtrings of an

inſtrument of muſic. Animals that are entirely glutinous, are notwithſtanding very ſenſible.

We then admit there is a fluid in the nerves, whoſe ſubtlety prevents our ſeeing it ; and which ſerves both for the propagation of ſenſible impreſſions, and muſcular motion.

The inſtantaneouſneſs of this propagation, and ſome other phenomena, indicate that there is a certain analogy between the nervous fluid and fire or light.

We know that all bodies are impregnated by fire. It abounds in aliment. It is extracted from it by the brain, from whence it paſſes into the nerves.

The ſeat of the ſoul, the immediate organ of feeling and thought, can be no other than a compoſition of this vital fire. The brain which we ſee and feel, muſt therefore only be the caſe or covering of the ethereal machine, which conſtitutes the real ſeat of the ſoul.

It may indeed be the germ of that ſpiritual and glorious body, which revelation oppoſes to the animal and vile.

The reſurrection, then, will only conſiſt in a prodigiouſly rapid unfolding of this germ, which lies hid in the brain.

Theſe ſenſes are the foundation of thoſe relations which the animal body bears to terreſtrial bodies. The ſeat of the ſoul, or the little ethereal machine that conſtitutes it, has parts correſponding with the groſſer ſenſes, ſince it receives motions from thence, and tranſmits them to the ſoul. Theſe parts, by the opening of the germ, will acquire a degree of perfection incompatable with the preſent ſtate of man. But this germ may likewiſe contain within it new ſenſes, which will diſcloſe themſelves at the ſame inſtant, and by multiplying in an almoſt infinite degree the relations of man to the univerſe, will aggrandize his ſphere, and render it equal to that of ſuperior intelligences.

An organized body, formed of elements analogous to thoſe of light, will, we may reaſonably ſuppoſe, ſtand in need of no repair. The ſpiritual body will preſerve itſelf by the mere energy of its mechaniſm.

And if light or æther do not gravitate at all, man in a glorified

a glorified ſtate will be enabled to tranſport himſelf at pleaſure into every point of ſpace, and will fly from planet to planet, with the ſwiftneſs of lightning.

The ſenſes, as they will then be brought into ſubjection to the ſoul, will no longer rule over her. Separated for ever from fleſh and blood, there will remain in her none of thoſe earthly affections which reſulted from them. Tranſported into the regions of light, the human underſtanding will preſent no ideas to the will but thoſe of the higheſt good. It will then have no other than lawful deſires, and God will be their conſtant and ultimate end. It will love him from gratitude; fear him from a principle of love; and will adore him as the ſupremely amiable being, and as the eternal ſource of life, perfection and happineſs.

CHAP. V.

Of the various Relations of terreſtrial Beings.

1. WE have ſeen, that all is relation in the univerſe, but we have only hitherto taken a diſtant view of this fruitful truth. We may now approach nearer to it, and beſtow our attention on the moſt intereſting particulars.

The union of ſouls to organized bodies, is the ſource of the moſt abundant and moſt wonderful harmony that exiſts in nature. A ſubſtance without extenſion, ſolidity, and form, is united to an extended, ſolid, and formed ſubſtance. A ſubſtance that thinks, and which has a principle of action in it, is united to a ſubſtance void of thought and purely paſſive. From this ſurpriſing connection there ſprings a reciprocal commerce

between

between the two ſubſtances : a kind of action and reaction, which conſtitutes the life of organized animated beings. The nerves, being variouſly agitated by objects, communicate their motions to the brain, and to theſe impulſes the perceptions in the ſoul correſpond, which are totally diſtinct from the cauſe that occaſions them.

The rays which proceed from an object ſtrike my optic nerve, I have a perception that points out to me the preſence of the object. They affect this nerve in a violent manner : I have a ſenſation which I expreſs by the term of pain.

The diverſity of ſenſes by which the ſoul receives the impreſſion of objects, produces a diverſity in her perceptions and ſenſations. The ſentiments occaſioned by the motion of the nerves of ſight, differ abſolutely from thoſe that are produced by that of the nerves of hearing. The ſenſe of feeling has no likeneſs to that of taſte. Theſe are different modifications of the ſoul, which correſpond to different qualities of the objects.

But how can the nerves, which do not ſeem ſuſceptible of a greater or leſs degree of bulk, length, compoſition, or tenſion, or of quicker or ſlower vibrations, occaſion in the ſoul ſuch a prodigious variety of perceptions as we experience ? Is there ſuch a relation between the ſoul and the machine to which it is united, as for certain perceptions to correſpond continually with the nerves of a determinate ſize, ſtructure, and tenſion ? Are there nerves appropriated to different corpuſcles, to the impreſſion whereof various perceptions are attached ? Are the pyramidal form of the papillæ of the taſte and feeling, the winding cavities of the ear, the different refrangibilities of the rays of light, ſo many proofs of the truth of this ? Be that as it may, we are ſufficiently convinced that the ſame ſenſible fibre is not liable at one and the ſame time to a multitude of different impreſſions. But this fibre is not only deſtined to tranſmit to the ſoul the impreſſion of the object ; it muſt alſo preſerve the remembrance

membrance of it; for a thouſand inſtances prove that the memory is connected with the brain: how then can it be imagined that the ſame fibre ſhould at once retain a multitude of different determinations? Nay, how can two ſuch different ſubſtances as the ſoul and body act reciprocally on each other? At this queſtion let us humbly caſt our eyes downwards, and acknowledge this is one of the great myſteries of the creation, which we are not permitted to be acquainted with. The various attempts that have been made by the moſt profound philoſophers, to explain it, are ſo many monuments raiſed to convince us both of the extent and weakneſs of the human mind.

2. The ſoul, being modified by impreſſions more or leſs ſtrong, re-acts in her turn on the nervous ſyſtem, maintains the motions there, and renders them more active or durable. From thence ariſe the paſſions, thoſe ſecret inclinations, thoſe reſtleſs appetites, which deſtroy the equilibrium of the ſoul, and impel her towards certain objects. Theſe are admirable inſtruments ſet to work by the wiſe Author of our nature; which, like favourable winds, cauſe the animated machines to float on the ocean of ſenſible objects!

The re-action of the ſoul on the nervous ſyſtem, ſeems alſo to be the principal ſource of divers ſenſations we experience, ſeveral of which come under the denomination of inſtinct or moral ſenſe.

Objects do not ſtrike immediately on the ſoul. She only receives impreſſions by interpoſed mediums. The ſenſes are the mediums. The action of objects, then is modified by them in a determinate relation to nature, or to the conſtitution of each medium. The aptneſs, either greater or leſs, wherewith ſenſible fibres yield to impreſſions from without, tranſmit them to the ſoul, and renew the remembrance of them there, together with the quality, and abundance of the humours, conſtitutes the temper. In animals, temper governs all. In man, reaſon regulates the temper: and the temper, when under due regulation, facilitates, in its turn, the exerciſe of reaſon.

The

The paſſions receive nouriſhment, grow, and become ſtrong like the fibres which are the ſeat of them. Learn then your temper, if it be vicious, you are to correct it; not to deſtroy it, for you would thereby deſtroy the machine itſelf; but ſkilfully to divert its courſe, and carefully to avoid every thing that may contribute to add new ſtrength to it, and ſwell the waters of ſuch a dangerous torrent.

3. The ſenſes are not only intended to raiſe in the ſoul perceptions of every kind; they likewiſe revive memory in her. A perception which is preſent to the memory does not eſſentially differ from that which the object excites. This produces perception by means of ſenſible fibres appropriated to it, and on which its action is diſplayed. The recollection of perception then depends on a motion which operates in theſe fibres, independently of the object. For whether the organ receives its motion from inteſtine cauſes, or from the object, the effect is the ſame with regard to the ſoul, and perception is inſtantly preſent to her.

Experience proves, that if any ſeries of perceptions whatever affects the brain for a certain time, it thereby contracts a habit of re-producing it in the ſame order. It is likewiſe certain that this habit appertains to the brain, and not to the ſoul. A burning fever, a ray of the ſun, or a violent commotion may deſtroy it, and ſuch cauſes influence only the machine.

All perceptions derive their origin from the ſenſes, and the ſenſes tranſmit to the ſeat of the ſoul, the impreſſions they receive from objects. But objects act on the organ by impulſion only. They impreſs then certain motions on the ſenſible fibres. So that a perception, or a certain ſeries of perceptions, are connected with one or divers motions which operate ſucceſſively on different fibres.

And ſince the reiteration of the ſame motions, on the ſame fibres, effects in them an habitual diſpoſition to produce them afreſh in a conſtant order, we may infer from thence, that the ſenſible fibres are ſo conſtructed as to produce in them changes or determinations more

or leſs durable, which conſtitute the precious groundwork of the memory and imagination.

But the ſenſible fibres are nouriſhed like all the other parts of the body: they aſſimilate or incorporate with themelves alimentary matter: they grow, and whilſt they receive nouriſhment, they continue to perform their proper functions. So that nutrition conduces to preſerve to the fibres theſe determinations, and cauſes them to take root there: for as the fibres increaſe, they acquire a greater degree of conſiſtence. We may hence diſcover the origin of cuſtom, that powerful queen of the ſenſible and intelligent world. The memory, by preſerving and recalling to the ſoul the ſigns of perceptions, by aſſuring her of the identity of the perceptions recalled, and of thoſe which have already affected her, by connecting preſent perceptions with the antecedent ones, forms in the brain a fund of knowledge, which increaſes in richneſs every day.

The imagination, being infinitely ſuperior to a Michael Angelo or a Raphael, delineates in the ſoul, a faithful image of objects; and from divers repreſentations which it compoſes, forms in the brain a cabinet of pictures, every part of which moves, and is combined with an inexpreſſible variety and ſwiftneſs.

The brain of man, then, may be conſidered as ſo many mirrors, wherein different portions of the univerſe are painted in miniature. Some of theſe mirrors hibit but a ſmall number of objects; while others preſent almoſt the whole of nature. What is the relation between the mirror of the mole and that of a Newton! What images were there in the brain of a Homer, a Virgil, or a Milton? What mechaniſm muſt that have been which could execute ſuch wonderful decorations! That mind which could have read the brain of a Homer, would have there ſeen the Iliad repreſented by the various exerciſe of a million of fibres.

4. Of all the ſenſes, the ſight is that which furniſhes the ſoul with the quickeſt, moſt extenſive, and moſt varied perceptions. It is the fertile ſource of the richeſt treaſures of imagination, and it is to that principal-

ly that the ſoul owes the ideas of beauty, of that varied unity which raviſhes it.

But by what ſecret mechaniſm are my eyes made capable of communicating to me ſuch lively, varied, and abundant perceptions? How do I diſcover with ſo much eaſe and quickneſs every object that ſurrounds me.

Three humours of different denſity, each lodged in a tranſparent capſule, divide the inſide of the globe of the eye into three parts. On the bottom is ſpread a kind of cloth, or very fine membrane, which is only the expanſion of a nerve, whoſe extremity terminates immediately at the brain. A black ſkin lines the whole inſide of the globe. At the fore part of it is a round orifice, which contracts or dilates itſelf according as the light is more or leſs ſtrong. Six muſcles, which are placed on the outſide of the globe, move different ways, and the rapidity of thoſe motions is exceſſive.

What need is there of theſe humours, this cloth, this tapeſtry, this aperture which contracts and dilates itſelf? The light comes to us from the ſun in a right line: but theſe rays become crooked, when the denſity of the mediums through which they paſs increaſes or diminiſhes. This is called the refraction of light.

To the property of refracting light, joins that of reflecting from the body it enlightens. There iſſue then luminous ſtreaks from all points of the objects, which bear the image of theſe points.

The humours of the eye are the lens of the camera obſcura: the cloth or retina are the paſte-board. The black ſkin which hangs within the ball performs the office of a ſhutter that excludes the light: it extinguiſhes the rays whoſe reflection would render the image leſs diſtinct; the ball, by contracting or dilating itſelf in proportion to the ſtrength of the light, moderates the action of the rays on the retina: the nerve placed behind this, communicates to the brain the various concuſſions it receives, to which divers perceptions correſpond.

5. Such

5. Such are the admirable relations which wiſdom has placed between our eyes and the light: thoſe which it has eſtabliſhed between light and the ſurfaces of different bodies, whence colours proceed, are not leſs worthy our attention.

A ray which falls on a glaſs priſm, divides into ſeven principal rays, each of which bear its proper colour. The oblong image which this refraction produces, affords ſeveral coloured ſtripes, diſtributed in a regular order. The firſt, reckoning from the upper part of the image, is red; the ſecond, orange; the third yellow; the fourth green; the fifth, blue; the ſixth, indigo; the ſeventh, violet. Theſe ſtripes do not glare: but the eye paſſes from one to the other by gradations or ſhades.

The rays which bear the higheſt colours, as the red, orange, and yellow, are thoſe that refract or curve the leaſt in the priſm. They are alſo ſuch as reflect the firſt, on inclining the inſtrument.

From thence it follows, that each ray has its fixt degree of refrangibility. Make one of theſe rays paſs through ſeveral priſms at the ſame time; it will afford you no new colours: but it will conſtantly retain its primitive colour, which is an invincible proof of its immutability. Preſent a lens to ſeven rays divided by the priſm, you will re-unite them into a ſingle ray, which will afford you a round image of a ſhining white. Take only five or ſix of theſe rays with the lens; you will have but a duſky white. Only reunite two rays; you will make a colour, that will partake of both. A ſtream of light then is a cluſter of ſeven rays, whoſe reunion forms white, and the diviſion of which produces ſeven principle and immoveable colours!

What is now the ſource of that infinite diverſity of colours, which embelliſhes every part of our abode? The particles which compoſe the ſurface of bodies, are ſo many little priſms variouſly inclined, which break the light, and reflect different colours. Gold divided into very thin plates appears blue, when oppoſed to broad day light. The greater or leſs thickneſs of the plates contributes then to the diverſity of colours. Whence proceeds that beautiful azure which

tinges

tinges the canopy of heaven? The ground of the heavens is black: this ground viewed through the body of air which ſurrounds us, muſt appear blue to us. Whence proceeds this ſmiling verdure which adorns our fields? The lamellæ of the ſurface of plants are diſpoſed in ſuch a manner, that they remit only green rays, whilſt they afford a free paſſage to others. If green pleaſes our ſight, it is becauſe it holds preciſely a medium between the ſeven principal colours. But who can remain inſenſible of the care which nature has taken to depart from uniformity in this caſe, by multiplying in ſo great a degree the ſhades of green? You admire this magnificent rainbow, which delineates at large to you the colours of the priſm: the beauty and vivacity of its ſhades raviſh you: you ſuſpect that nature muſt have been at a vaſt expenſe to compoſe this rich girdle. Some drops of water, on which the light breaks and reflects in different angles, are the ſole cauſe of it.

You are ſtruck with the ſplendid gilding of ſome inſects: the rich ſcale of fiſhes attract your notice: nature who is always magnificent in deſign, and frugal in execution, produces theſe brilliant decorations at a ſmall charge: ſhe only applies a brown thin ſkin on a whitiſh ſubſtance: this ſkin performs the office of varniſh to our gilded ſkins; it modifies the rays which iſſue from the ſubſtance it covers. The gloſſy green of the leaves of plants is owing to the ſame art. They owe their luſtre and ſhades to a fine ſmooth, tranſparent, gloſſy, and whitiſh membrane which clothes a ſubſtance that is always of a rough green, and of a ſtronger or fainter dye. It is this green modified by this membrane, which conſtitutes the colour peculiar to leaves of every ſpecies.

It is apparently the ſame with regard to the enamelling of flowers, and perhaps likewiſe to the colouring of fruits. This is a new branch of optics which were it dived into as it deſerves, might be attended with ſome intereſting conſequences.

The direct light of the ſun, or that of the day only, tinges the leaves, as it colours that of fruits. Leaves, whilſt they are encloſed within the bud, are whitiſh or yellowiſh.

yellowiſh. They preſerve this colour, if obliged to grow in a tube of blue paper, where the air and heat may have free acceſs. The plant then ſtars, as the gardeners term it, ſending forth an exceſſively long and ſlender ſtalk, and the leaves unfold themſelves but very imperfectly. The light is in a continual and very rapid motion: it acts perpetually on the ſurface of bodies, which it penetrates more or leſs. By its ſmall reiterated ſtrokes on leaves, it modifies the ſurface of them by little and little, and inſenſibly diſpoſes it to reflect the green colour.

Colours then in objects are only a certain diſpoſition of parts totally diſtinct from the perceptions which they cauſe in the ſoul. It is the ſame with reſpect to all our perceptions and ſenſations. The ſenſes, by preſenting to us bodies under different appearances, ſhew us their various qualities; and to theſe qualities different ideas in the ſoul correſpond. We conclude from hence, that the ſame objects do not affect all ſenſible beings in an equal manner. It is even doubtful whether two individuals of the ſame ſpecies have preciſely the ſame perceptions in preſence of the ſame object.

Were we to contemplate the world by the organs of all thoſe ſenſible beings which inhabit it, we ſhould perhaps ſee as many worlds as we ſhould employ glaſſes. What difference would there appear in the mulberry-tree, examined through the organs of a ſilk-worm, from our conception of it! What diverſity between the ſtamina viewed thro' the eyes of bees, and thoſe which the botaniſt obſerves! How extenſive would be the knowledge of that being, who could be acquainted with all theſe different impreſſions!

6. Fire, which is diſperſed through all nature, offers to us an infinity of properties: let us confine ourſelves to give an account of the moſt intereſting. Fire being ſubtle, elaſtic, and continually agitated, penetrates all bodies. It warms, dilates, burns, melts, calcines, vitrifies, volatilizes, and diſſipates them, according to the

the nature of their compoſition or principles. This ſubtle element becomes viſible only by borrowing a body. It ſecretly unites itſelf to an inflammable and unknown ſubſtance, and provided with this body, unites itſelf to other bodies, and enters into their compoſition. It is by means of the ſame union that it becomes ſenſible in electrical experiments, ſometimes in the form of luminous tufts, ſometimes in that of crowns, flaſhes, ſparks, and that it fulminates, burſts, ſtrikes, pierces, burns, inflames.

By a gentle agitation fire enlivens all organized bodies, and conducts them by degrees to their perfect growth. It foments the branch in the bud, the plant in the grain, the embryo in the egg. It gives ſuitable preparations to our food. It ſubdues metals to our uſe, over the formation of which it preſides. By that we are enabled to give matter, all thoſe forms which our neceſſities or conveniences require. To that we are indebted, in a particular manner, for that tranſparent matter, which being ſtretched out into thin leaves, or faſhioned like tubes, vaſes, globes, lenſes, furniſhes us with various inſtruments, and enriches us with new eyes, which help us to diſcover the ſmalleſt objects, and bring nigh to us the moſt remote.

From the action of fire on earth, ſulphur, oils, and ſalts, the various ſpecies of fermentations, and mixtures reſult, which are the objects of the reſearches of the chymiſt, and the ſoul of the three kingdoms. Being concentered by lenſes or mirrors of every kind, it acquires a ſtrength greatly ſuperior to that of the hotteſt of our actual fires, and in an inſtant reduces green wood to aſhes, calcines ſtones, melts and vitrifies metals.

Being excited, collected, condenſed, modified, extracted, directed, and applied by electrical machines, it becomes the fruitful ſource of a thouſand phenomena, which art diverſifies every day. Sometimes, when extracted from a globe of glaſs, it runs with an inconceivable rapidity along an iron wire, and cauſes light bodies, placed at a league diſtance from the globe, to feel the impreſſion of it. Applied by the ſame means

to

to paralytic limbs, it reſtores life and motion to them. Being preſent in all parts of the atmoſphere, it collects itſelf in ſtormy clouds, from whence it is again extracted by art; and a Le Monnier, equal to the fabulous Jupiter, holds the thunderbolt, and diſpoſes of it at his pleaſure. It is likewiſe fire that communicates to air and water, when reduced into vapours, that prodigious force which renders them capable of ſhaking the earth, and breaking the hardeſt bodies.

Laſtly, it is fire, that by penetrating fluids, preſerves to them their fluidity. As it is exact itſelf, in putting itſelf in equilibrio, it paſſes from thoſe bodies where it is moſt abundant to thoſe where it is leaſt ſo, and carrying with it the moſt volatile particles, it depoſits them on the ſurface of the latter, where they appear in the form of vapours, exhalations or miſts.

7. The air, by its fluidity, thinneſs, weight, and ſpring, is next to fire the moſt powerful agent in nature. It is one of the great principles of the vegetation of plants, and of the circulation of liquors in all organized bodies. It is the receptacle of the particles which exhale from different matters: and had we eyes ſufficiently piercing, we ſhould ſee it in the abridgment of all the bodies that exiſt on the ſurface of our globe. From vapours and exhalations which it carries in its boſom, and diſperſes into all parts, are produced aqueous and fiery meteors, which are ſo uſeful, but ſometimes dreadful.

The air does not only receive bodies: it even enters into their compoſition. When diveſted of its elaſticity, it unites itſelf to the particles which compoſe them, and augments their bulk. But being more unalterable than gold, it reſumes its former nature, when theſe bodies change or are diſſolved. Being diſtributed in its equilibrium, it ſwells the ſails of our ſhips, and conveys to our countries thoſe rich fleets that cauſe plenty. Becoming impetuous, it cauſes tempeſts and hurricanes; but even this impetuoſity is not without its uſe: the air by this means diveſts itſelf of noxious vapours, and the waters being ſtrongly agitated, are preſerved from a fatal corruption.

Laſtly,

Laſtly, the air is the vehicle of ſounds and odours, and under theſe new relations it is eſſentially allied to two of our ſenſes. The partial vibration which commotion excites in a ſonorous body, communicates itſelf to all the globules of air that immediately encompaſs this body. Theſe globules cauſe the like vibrations in thoſe contiguous to them: and this continues in the ſame manner to greater diſtances than we are able to determine. A fine and elaſtic membrane, ſpread at the bottom of the ear like the parchment of a drum, receives theſe concuſſions, and conveys them to three ſmall bones placed end to end, that communicate them in their turn to certain bony and winding cavities, lined on their inſide with nervous filaments, which join to the brain by a common trunk. The greater or leſs degree of ſwiftneſs of theſe vibrations produces ſeven principal tones, analogous to the primitive colours. From the combined relation of various tones, harmony proceeds.

The infinitely ſmall particles that are continually detached from the ſurface of odoriferous bodies, float in the air, which tranſports them every where, and applies them to the nervous membranes that are diſtributed in the inſide of the noſe. The concuſſions which theſe corpuſcles occaſion therein, paſs afterwards to the brain by the lengthening of the nervous filaments.

8. All climates have their productions: all parts of the earth their inhabitants. From the frozen regions of the bear, to the burning ſands of the torrid zone, all is animated. From the top of the mountains to the bottom of the vallies, every thing vegetates and reſpires. The waters and the air are peopled with an infinite number of inhabitants. Plants and animals are themſelves little worlds that nouriſh a multitude of people, as different from each other in their figure and inclinations as the great people are which are ſcattered over the face of our globe. What am I ſaying? The ſmalleſt atom, the leaſt drop of liquor are inhabited. Wonderful harmony, which by thus ſuiting different productions to different places, leaves none abſolutely deſert!

9. A re-

9. A reciprocal commerce connects all terreſtrial beings. Inorganized beings anſwer to organized as to their centre. The latter are deſigned for each other. Plants are allied to plants. Animals to animals. Animals and plants are linked together by their mutual ſervices. Behold how cloſely this young ivy entwines itſelf round this majeſtic oak. It draws its ſuſtenance from it, and its life depends on that of his benefactor. Ye great ones of the earth, ye repreſent this oak. Refuſe not your ſupport to the indigent: ſuffer them to approach you, and to obtain from you ſufficient to relieve their neceſſities.

Conſider this caterpillar thick-ſet with hair: the birds dare not touch it: notwithſtanding which it ſerves them for food: by what means? a fly pierces the living caterpillar. She lays her eggs in his body. The caterpillar remains alive. The eggs hatch. The young ones grow at the expenſe of the caterpillar, and are afterwards changed into flies, which ſerve for ſuſtenance to the birds.

There are continual wars betwixt animals; but things are ſo wiſely combined, that the deſtruction of ſome of them occaſions the preſervation of others, and the fecundity of the ſpecies is always proportionable to the dangers that threaten individuals.

10. All is metamorphoſis in the phyſical world. Forms are continually changing. The quantity of matter alone is invariable. The ſame ſubſtance paſſes ſucceſſively into the three kingdoms. The ſame compoſition becomes by turns a mineral, plant, inſect, reptile, fiſh, bird, quadruped, man.

The organized machines are the principal agents of theſe tranſformations. They change or diſſolve all matters that enter within them, and that are expoſed to the action of their ſecret ſprings. They convert ſome into their own ſubſtance; others they evacuate under divers forms, which render theſe matters proper for entering into the compoſition of different bodies. Thus animals that multiply prodigiouſly, as ſome ſpecies of inſects, have perhaps for their principal end that of metamorphoſing a conſiderable quantity

tity of matter, for the uſe of different compounds By that means the vileſt matters give birth to the richeſt productions: and from the boſom of putrefaction there iſſues the fineſt flower, or the moſt exquiſite fruit!

The Author of Nature has left nothing uſeleſs. What is conſumed of the duſt of the ſtamina in the generation of plants, is very trifling, if compared with the quantity each flower furniſhes. Wiſdom itſelf then has created the induſtrious bee, that makes uſe of the ſuperfluous part of this duſt with ſuch art and œconomy, as could not be too much admired in the moſt ſkilful geometricians.

The earth enriches us every day with new gifts, whereby ſhe would at length be exhauſted if what ſhe ſupplies us with were not reſtored to her. By a law, which we do not pay a proper attention to, all organized bodies become uncompounded and inſenſibly change in the earth. Whilſt they ſuffer this kind of diſſolution, their volatile parts paſs into the air, which tranſports them every where. So that animals are buried in the atmoſphere as well as in the earth and water; we may even doubt whether that portion which the air receives be not the moſt conſiderable in bulk. All theſe particles diſperſed here and there, ſoon enter into new organical wholes, deſtined to the ſame revolutions as the former. And this circulation, which has ſubſiſted from the beginning of the world, will continue as long as it endures.

CHAP.

CHAP. VI.

Of Vegetable Œconomy.

1. THERE is no ſource of phyſical relations that is more abundant than the œconomy of organized bodies. Let us caſt an eye on what it offers to us on the moſt intereſting nature. Our plan does not lead us to dive into a ſubject that exhauſts the ſegacity of a philoſopher.

Original œconomy, taken in the moſt extenſive ſenſe, is that ſyſtem of laws according to which the vital functions operate in organized bodies.

Conſidered in a leſs view, organical œconomy preſents us with two claſſes of objects. The firſt comprehends the ſtructure, arrangement, and exerciſe of the different parts of organized bodies. The ſecond comprizes the various effects that reſult from organization.

2. The plant vegetates, is nouriſhed, grows, and multiplies. The ſaline, unctuous, and ſubtle ſlime, which the water ſeparates from the coarſe earth, and keeps in a diſſolved ſtate, is the principal nutriment of plants. The different ſpecies of manure only contribute to the fertilizing of land, in proportion, as they introduce into it a great quantity of a ſpongy powder or active ſalt. If a natural philoſopher ſucceeds in raiſing plants, and cauſing them to bear flowers and fruits in other matters than earth, for inſtance, in the powder of rotten wood, deal, ſaw-duſt, very fine ſand, moſs, cotton, paper, ſponges: the reaſon is, becauſe ſeveral of theſe matters either change inſenſibly in the ground, or actually contain earthy parts, or the water which moiſtens

moiſtens them is itſelf charged with theſe particles, which the organs extract, prepare, and aſſimilate.

After having been admitted into the body of the root by the extremity of the fibres, the nutritious juice riſes into the ligneous fibres, from the trunk or ſtalk, and paſſes into the utricles that adhere to them. It is there prepared and digeſted. It afterwards enters into the proper veſſels, under the form of a coloured fluid, more or leſs thick, which we may conjecture to be with reſpect to the plant, what the chyle or blood is to the animal. Being filtred by finer or more winding pipes, it is at laſt conveyed to all the parts, whereto it unites itſelf, and increaſes their bulk.

The extreme fineneſs of the canals for the ſap, which renders them in ſome meaſure capillary pipes, the action of the air on the elaſtic ſheaths of the air-vents, and the impreſſion of theſe laſt on the ligneous fibres they contain, or by which they are comprized, the heat that rarefies the ſap, and above all that which, by acting on the ſurface of the leaves, draws thither the ſuperfluous nutritious juice, and occaſions the evaporation of it, ſeem to be the principal cauſes of the aſcent of this fluid in plants. The quantity of nutriment, which a plant derives from the earth is in proportion to the number and ſizes of its leaves; the ſmaller or fewer in number the leaves are, the leſs it draws. The nutrition of vegetables is likewiſe effected immediately by their leaves. They do not only ſerve for raiſing the ſap, preparing it, and diſcharging its ſuperfluity; they are moreover a kind of roots that pump from the air the juices they tranſmit to the neighbouring parts.

The dew, which riſes from the ground, is the principal foundation of this aereal nouriſhment. The leaves preſent it to their inferior ſurface, which is always furniſhed with an infinite number of ſmall pipes that are always ready to abſorb it. And that the leaves may receive no prejudice in the exerciſe of this function, they are diſpoſed with ſuch art on the ſtalk and branches, that thoſe that immediately precede do not cover ſuch as ſucceed them. Sometimes they are placed alternately on two oppoſite and parallel lines. Some-

times

times they are diſtributed by pairs, that croſs each other at right angles. Sometimes they are ranged on the angles of polygons circumſcribed on the branches, and ſo diſpoſed that the angles of the inferior polygon correſpond with the ſides of the ſuperior. At other times they aſcend the whole length of the ſtalk and branches on one or more parallel ſpiral lines.

Ye ſceptics, can you inform me why plants are diſpoſed with ſo much art? You will perhaps deny that plants imbibe the dew by their inferior ſurface! But what would you ſay, were one to inform you, that among leaves exactly reſembling each other, and taken from the ſame tree, ſuch as have been ſteeped by their inferior ſurfaces in veſſels of water, have continued green for the ſpace of whole weeks, and even months; whilſt thoſe that have been placed, by way of experiment, with their upper ſurface in the water, periſhed in a few days?

Herbs that are always immerſed in the thickeſt beds of dew, and that grow much faſter than trees, have their leaves formed in ſuch a manner, that they pump in the moiſture nearly alike by both ſurfaces, ſometimes more copiouſly by the upper ones.

Obſerve laſtly, that the inferior ſurface of the leaves of trees is commonly leſs ſmooth and gloſſy and of a paler colour than the oppoſite ſurface. This remarkable difference between the two ſides of the leaf, ſufficiently indicates that they have different uſes.

3. By a mechaniſm which is very ſimple, the root forces itſelf into the earth; the branches ſhoot out on each ſide: the leaves expoſe their ſuperior force to the open air, and their inferior ſurface to the earth, or the inner part of the plant. Sow a ſeed the contrary way; you will obſerve the radicle and little ſtalk to bend backwards; the former in order to reach the earth, and the latter to gain the air. Keep a young ſtalk inclined; its extremity will grow upwards. Bend the branches of all ſorts of plants; cauſe the inferior ſurface of their leaves to turn towards the ſky; you will

will ſoon perceive that all theſe leaves will turn back again, and reſume their former poſition: which motion will be executed with a quickneſs proportionate to the heat of the ſun, or ſuppleneſs of the leaves. Sow different kinds of ſeeds in a cloſet or cellar: carry thither ſome ſmall twigs having their extremity ſteeped in veſſels full of water. The leaves of the young plants and thoſe of the twigs, will incline their upper ſurface to the windows or air-holes.

Conſider the leaves of divers ſpecies of herbaceous plants; of the mallow for inſtance; you will remark that they follow the courſe of the ſun. In the morning you will ſee them preſent their upper ſurface to the eaſt; towards the middle of the day this ſurface will face the ſouth: in the evening it will be turned to the weſt. At night or in rainy weather theſe leaves will be horizontal, their inferior ſurface looking towards the earth.

Trace likewiſe the leaves of the acacia; as ſoon as they are heated by the ſun, you will obſerve all their foliages draw together by their upper ſurface. They will then form a kind of gutter turned towards the ſun. In the night, or in moiſt weather you will ſee the foliage turned the contrary way, and contracting themſelves by their inferior ſurface. They will then form a gutter that will face the earth.

4. Do not ſeek for circulation in plants; as they are more ſimple than animals, every thing in them is performed with leſs apparatus.

In the day-time the action of the heat on the leaves, draws to them in abundance the nutritious juice. The ſmall excretory veſſels, that appear in the forms of globules, pyramids, filaments, ſeparate the more aqueous or groſs parts of the juice that riſes from the root. The air contained in the trachæ of the ſtalk and branches, by dilating itſelf more and more, preſſes the ligneous fibres, and by that means accelerates the courſe of the ſap, at the ſame time that it cauſes it to penetrate into the neighbouring parts.

When

When night approaches, the inferior ſurface of the leaves begins to perform one of its principal functions. The little mouths it is provided with open themſelves, and receives the vapours that float in the atmoſphere. The air of the trachæis confined with in them; their diameter is leſſened, the ligneous fibres being leſs preſſed, enlarge themſelves, and admit the juices conveyed to them from the leaves. Theſe juices join themſelves to the reſidue of that which had ariſen in the day-time, and the whole maſs tends towards the roots.

This ſeems to be exactly the mechaniſm to which the motion of the ſap may be reduced. You now ſee more clearly the deſign of the direction of the leaves, and of their admirable reverting. The inferior ſurface being intended for imbibing the dew, ſhould face the earth, from whence this vapour riſes gradually at ſun ſet. But when I ſay that the principal office of this ſurface, at leaſt in trees and ſhrubs, is to receive the dew, I would not infer that the oppoſite ſurface is incapable of it: that may perhaps abſorb vapours that are more rare.

Experiments that are well made ſeem to prove that the inferior ſurface of the leaves of trees ſerve likewiſe for inſenſible perſpiration. Thoſe leaves in which this ſurface was endued with a matter impenetrable by water, drew in and tranſpired much leſs, in an equal time and with the ſame management, than leaves of the ſame ſize and likeneſs, whoſe inferior ſurface had not been endued with ſuch a varniſh. It ſeems to have reſulted from the ſame experiments, that there is but little perſpiration by the upper ſurface. We may thence infer that one of its principal functions is, to ſerve for a ſhelter or defence to the lower ſurface: and that no doubt, is the uſe of the gloſſy varniſh obſervable on the ſuperior ſurface. All which agrees with the almoſt ſpontaneous motions and directions of the leaves, and with their ſymmetrical diſtribution round the ſtalks and branches.

5. The plant being encloſed in miniature within the fruit or ſeed, is there encompaſſed with a quantity of flour, which after being diluted by the water that has

penetrated

penetrated the encloſures, ferments and furniſhes the germ with its firſt nouriſhment. Being moiſtened by the delicate milk, in proportion to its weakneſs, it grows from day to day. In a ſhort time its coverings become incommodious; it endeavours to diveſt itſelf of them, and puſhes forth a little root, which proceeds to ſeek for more nouriſhing juices in the earth. The little ſtalk appears in its turn. As it is deſtined to live in the air, it pierces the earth, and darts perpendicularly into the aereal fluid. Sometimes it carries along with it the remains of the teguments that had enwrapped it in the germ ſtate: at other times it is accompanied by two leaves, which are very different from thoſe of a mature age; theſe are the ſeminal leaves, whoſe principal uſe is probably to refine the ſap.

Though it is diveſted of its ſwaddling-clothes, if we may ſo term them, the young plant is not at full liberty. It is not in a condition to be expoſed ſo early to the impreſſions of the air and ſun. All the parts remain for a ſhort time folded together, nearly as they were in the ſeed. But the root, by extending and ramifying itſelf more and more, conveys to the veſſels a conſiderable quantity of ſap, which ſoon opens all the organs.

At its firſt appearance the plant is almoſt gelatinous. It aſſumes by little and little a greater degree of conſiſtence by the incorporation of the juices which flow to it from all parts. That part of the ſtalk next the root increaſes in bulk, extends itſelf, and hardens firſt of all. As the hardening augments, the extenſion diminiſhes. At length it entirely ceaſes in this part, and continues in that which immediately follows. Such is the nature of the progreſſion obſerved in the whole plant.

Wood, whoſe hardneſs is ſometimes equal to that of ſtone, is formed of a ſucceſſion of concentric layers, that are detached every year from the inſide of the rind, and harden as they advance in age.

6. Vegetables multiply by ſeed, ſhoots, and ſlips. The piſtil and ſtamina are to plants what the organs

of

of generation are to animals. The former encloſes the ſeed; the fine powder of the latter fecundates it. Both ſexes are frequently united in the ſame ſubject: and thoſe ſpecies are real hermaphrodites. Others bear the piſtil on one branch, and the ſtamina on another. A third ſort are like the greater part of animals, diſtinct males and females. The former are furniſhed with a piſtil, and the latter with ſtamina. This is all we know with regard to the generation of plants.

When the ſtamina are cut off, the ſeed remains unfruitful. The ſame thing happens when any one that has piſtils has not in its neighbourhood another provided with ſtamina. The piſtil is always ſo diſpoſed as to be able to receive the duſt of the ſtamina. Its top is perforated with holes proportioned to the diameter of the grains of this duſt, and its inſide is divided into ſeveral canals, whoſe diameter diminiſhes the nearer they approach to the bottom. At the baſe of the piſtil the ſeed is depoſited. Every grain of the duſt of the ſtamina is a box, wherein floats, in a kind of very thin vapour, an infinite multitude of other very minute grains. This box opens itſelf to the moiſture, and diſcharges a ſmall miſt of globules or grains.

The ſhrinking of the trunks indicates that the containing globules do not reach to the bottom of the piſtil: but the contained globules or grains are ſet at liberty by the action of the moiſture which the trunk imbibes, which, by opening the little box that encloſes them, permits them by this means to penetrate to the ovary.

7. Vegetables multiply by ſhoots. They puſh forth from the circumference of their root ſeveral ſuccours, which become plants themſelves, and propagate their ſpecies in like manner. The branches and young ſhoots may likewiſe be conſidered as ingrafted on the principal plant making one body with it. The germs which are diſperſed within the plant, infold themſelves there without any ſenſible fecundation, and reach to the ſurface of the bark. They appear there in the form of a ſmall oblong and rounded body, compoſed of ſeveral parts, ranged in a very regular man-

ner, and ſhaped like tubes, ſhells, &c. This little body is the bud, which like the ſeed encloſes the young plant under ſeveral coverings, all the parts of which are completed with abundance of art.

The little ſtalk ſhoots forth a ſimilar bud at its upper extremity. This bud opens, and produces a ſecond ſtalk, grafted on the firſt, which it lengthens. This new ſtalk produces a third; the third a fourth, ſo on ſucceſſively. When the tree has attained its full growth, it is compoſed of a ſeries of ſmall trees, placed end to end. It is the ſame with reſpect to branches and boughs, all having one and the ſame life, and forming only one organical whole.

Bulbous plants, inſtead of young ſhoots, ſend forth ſuckers. The bulb, which is formed of ſeveral membranes, or coats placed on each other, contains, in like manner as the ſeed and bud, a plant in miniature. The ſucker is a ſmall bulb that ſhoots out on the ſides of the principal one, and which is deſigned to ſucceed or replace it. Sometimes this replacing is performed with ſuch quickneſs and circumſtances as are very ſurpriſing. Whilſt the principle bulb is waſting, the ſucker thickens and ſpreads itſelf, and in a ſhort time becomes the principal bulb.

We may compare this bulb to a ſpecies of earth, that exhauſts itſelf in order to furniſh ſuitable juices to the young plant. It may alſo be looked upon as a placenta, that filtres and prepares the nutritious juice. The leaves of ſome herbaceous plants form ſpherical maſſes that are pretty compact, and ſeem to perform the office of a bulb. The head of a cabbage ſpends and waſtes itſelf in order to contribute to the unfolding of the minute ſtalk it contains. Place one of theſe heads on a veſſel full of water, and it will exhibit to you the ſame phenomena as the bulb of a flower.

8. The branches that bend down from certain trees to the earth, take root there, and become themſelves young trees. Human induſtry carries this kind of multiplication to a much greater extent. By means thereof,

of, a ſingle branch or root, divided into ſeveral parts, becomes ſo many individual plants. What do I ſay? It can even cauſe a tree to be produced from the ſmalleſt ſhred of a leaf. Such is the multiplication from ſlips.

The organs eſſential to life being diſperſed throughout the whole body of the ſubject, the ſlip that is detached from it, and planted in the earth, is of itſelf capable of forming new productions; it has every thing neceſſary for the unfolding of the radicles and buds. Thus a ſingle leaf takes root, and vegetates by its own ſtrength.

There is another kind of multiplication that is very remarkable, which conſiſts in planting one or more ſlips, not in the earth, but in the trunk or branches of a living tree. This is grafting; the firſt idea of which may perhaps have been owing to the accidental union of two branches or two fruits.

The next cauſe of the union of the graft with its ſubject, is in the intercourſe of the ſap-veſſels with each other; and this intercourſe depends ultimately on the relation of their parts, and particularly on that of their conſiſtence, and the liquors contained in them. By the aſſiſtance of a graft the gardiner cauſes the wild ſtock to produce the fineſt fruits, he gives youth to trees, and gathers plumbs from the almond tree, and pears from the aſh. Filtrating, and the preparation of the juices of the ſubject by the veſſels of the graft, occaſion theſe productions. The roll which is always formed at the inſertion, and is compoſed by the interweaving of a prodigious number of fibres, is one of the principal inſtruments of theſe preparations. The more or leſs perfect analogy of the juices proper to the ſubject with thoſe that are peculiar to the graft, favours in a greater or leſs degree the unfolding of the latter. The nearer or more diſtant relation between the time in which the ſap in the ſubject continues, and that in which the graft has been accuſtomed ſo to do, contributes likewiſe more or leſs to the ſucceſs of the operation.

9. The body of the plant is in a continual ſtate of motion. It always tends to produce, either the bark, a bud, or a root. Make an inciſion in a tree; the wound will cicatrice. A greeniſh roll will in a ſhort time be ſeen at the top of the wound, afterwards on the ſides, and at length towards the bottom. This roll is a new rind, which is about to cover the wood again, without uniting to it. Obſerve what paſſes with reſpect to this; you will perceive in it certain diſtinct and glutinous nipples, and ſmall, reddiſh ſpots diſperſed here and there, which you will find to be a a growing bark. A matter that is partly tranſparent, whitiſh and mucilaginous will ſeem to raiſe up this bark. All theſe glutinous ſubſtances will thicken, increaſe in length, and become ſtronger, and in a little time what was at firſt of a gluey nature will be herbaceous, cortical and ligneous. The cicatrice will at length entirely cloſe itſelf, and reſtore the communication between all the veſſels.

The wood does not only differ from the bark by its denſity, but it has likewiſe organs that are not to be met with in the latter. It ſeems to be peculiarly poſſeſſed of air-veſſels. When a new rind ſeems to convert itſelf into wood, this converſion is only in appearance. Nature does not create more air-veſſels than are ſuited to one entire plant. But a multitude of fibres that are deſtined to become wood, pre-exiſt under the new rind, and unfold themſelves with it and by it, as we ſee the butterfly unfold itſelf in and by the caterpillar. Whilſt wood is nothing more than a mucilaginous drop, it is not on that account the leſs wood, than when, being transformed into a pillar, it is made to ſupport the enormous weight of an edifice.

In the union of the graft with its ſubject, we likewiſe perceive a glutinous ſubſtance to ſpring from each of them, which ſpreads, ramifies, and is formed into a ball in both, becoming by degrees herbaceous, cortical, ligneous, and compoſes above the inſertion a roll which entirely covers it. So that the whole body of the plant is furniſhed with ſmall fibres on the inſide, which only wait for favourable circumſtances to diſ-

play

play themſelves. Theſe circumſtances are a wound, an inciſion, or a ſimple ligature. Theſe fibres are the elements of cortical or ligneous beds, which by ſpreading themſelves on all ſides, furniſh the neceſſary repairs. The wound, inciſion, and ligature, occaſioning the nutritious juices to flow towards theſe inviſible fibres, expand them, and render them perceptible to us.

What theſe fibres perform in the regeneration of the bark or wood, the germs effect in the reproduction of a branch or young ſhoot. The fibres of the bark or wood do not unite themſelves into bunches, in order to compoſe a bud or branch in miniature. This branch is already completely formed in its germ: it there poſſeſſes the elements of all the beds, whether cortical or ligneous, which it will hereafter exhibit under different proportions.

CHAP.

CHAP. VII.

Of Animal Œconomy.

1. THE nerves, which extend themſelves into all parts from the brain, are diſtinguiſhed into ſeveral principal diviſions, that are more or leſs numerous, or more or leſs extended. Each diviſion reaches to the part for which it is deſtined, and whoſe ſtructure correſponds with the functions appointed for it to exerciſe.

Feeling, ſight, hearing, taſte, and ſmell, are five kinds of ſenſes, which contain under them an almoſt infinite number of ſpecies. The ſhaking which the mediate or immediate impreſſion of objects produces on the nerves, give birth to thoſe different kinds of ſenſations, which may all be reduced to feeling, of which they are properly only modifications. The organs of the ſenſes are the inſtruments of theſe modifications. The number, extent, and delicacy of the ſenſes, conſtitute the degree of animal perfection.

The nerves, which ſeem to reſemble the ſtrings of a muſical inſtrument, are not ſtretched like them. Some animals are endued with an exquiſite ſenſation, that are themſelves little otherwiſe than a thick jelly: how then can we admit of elaſtic ſtrings in this jelly? While the fœtus is altogether gelatinous, it regulates at that time its members. With what amazing ſwiftneſs then muſt the impreſſions of objects communicate themſelves to the ſoul, and with what wonderful celerity muſt the members obey the will! Thus we are led to ſuppoſe in the nerves a very ſubtle and elaſtic fluid,

fluid, whoſe motions, being analogous to thoſe of light or electrical fluid, produce all the phenomena of ſight. The animal ſpirits are this fluid, which the brain extracts and prepares, and continually conveys into the nerves, and by the nerves into all parts, which it nouriſhes, moves, and animates.

2. An animal had in vain received ſenſes, by means of which it can diſtinguiſh between what is uſeful or hurtful, if it were not able to give itſelf any motion for the attaining the one, and avoiding the other. It is therefore furniſhed with organs that procure to it this faculty. Theſe organs are the muſcles, which by the dilatation and contraction, and by the lengthening and ſhortening of the fibres that compoſe them, communicate to all parts the motions, which are ſuited to the wants of the animal.

It is evident from experiments, that the nerves contribute to the exerciſe of the muſcles. The ſpirits which they diſperſe therein, inſinuate themſelves into all the veſicles, dilate them, and by that means put the organ into action.

One property of the muſcular fibre (whoſe effects are diverſified a thouſand ways, the cauſe of which is concealed from us) is that, by virtue whereof it contracts itſelf on the touch of any body either ſolid or liquid. This is called irritability. By means of this, different parts of the animal continue to move, after they have been ſeparated from the entire body; and the heart when detached from the breaſt, performs a number of pulſations, which ceaſe as ſoon as the blood in the cavity is evacuated.

3. From that part which gives admittance to the food to that from whence iſſue the remains of the groſſer aliment, there is one continued canal, which is formed, differently in different parts of its extent. There are three principal parts diſtinguiſhed in it, the œſophagus, the ſtomach, and the inteſtines. All theſe are formed of various membranes laid on each other, and which are themſelves compoſed of fibres differently interwoven. The muſcles, wherewith one or ſeveral

of

of theſe membranes are furniſhed, impreſs divers motions on the organ, the principal of which, called the periſtaltic motion, bruiſes the aliment, and forces it from place to place.

The œſophagus receives the groſſer nouriſhment, and tranſmits it to the ſtomach; that prepares it: it afterwards paſſes into the inteſtines, where it undergoes new preparations. From thence it enters into ſome very ſmall veſſels, that convey it to thoſe of circulation, where it aſſumes the name of blood.

Whilſt the moſt delicate part of the aliment is ſubject to all theſe preparations, the groſſer part is evacuated by different ways. Sometimes the animal diſcharges it as a ſediment; ſometimes, being transformed into a ſubtle liquor, it is carried to the ſurface of the ſkin by an infinite number of very fine veſſels, whoſe exterior apertures are ſometimes ſo ſmall, that a grain of ſand is capable of covering ſeveral thouſands of them.

Other veſſels, which, like them, communicate with the ſurface of the ſkin, pump in the vapours that float in the air, and convey them into the blood.

4. Circulation is that perpetual motion by which the blood is conveyed from a point internally to the extremities, and flows back again from the extremities to the ſame point. The point from whence the blood ſprings, is called the heart. It has two motions, one of contraction, or ſyſtole, by means of which it forces out the blood contained in its cavity; the other of dilatation, or diaſtole, by which it receives the blood again.

Two kinds of veſſels join to the heart: the arteries, which convey the blood to the extremities: and the veins, which carry it back from the extremities to the heart.

The arteries, have, like the heart, their ſyſtole and diaſtole, and divide and ſubdivide themſelves, as do the veins, into an infinite number of branches which diminiſh in diameter in proportion to their diſtance from their origin. The perpetual motion of circulation prevents the corruption and extravaſation of the nutritious fluid, rectifies it more and more, and

diſpoſes

diſpoſes it inſenſibly to renew the nature of the animal.

5. Reſpiration comprehends two alternate motions; one of inſpiration, which gives admittance to the air within; the other, of expiration, which expels it, filled with the vapours of the animal.

The lungs are the principal inſtrument of reſpiration. They are principally formed of a collection of cartilaginous and elaſtic veſſels, which after being divided and ſubdivided into a prodigious number of branches, meet in different parts, and terminate at one or more common trunks, called tracheæ, or air-veſſels, whoſe aperture is on the outſide of the body. The ramifications of the air-veſſels are connected with the veſſels of circulation, and accompany them in their paſſage through the lungs.

6. The blood is that rich fund from whence nature derives that diverſity of materials ſhe employs with ſo much art in the conſtruction of her wonderful edifice. This, as it goes from the heart, meets here and there on its paſſage, with certain organical, and as it were knotted maſſes, in which it is deprived of part of its principles.

We cannot yet penetrate the true mechaniſm of ſecretions: we can only faintly perceive, that they may operate by a gradual diminution of the veſſels which proportions them to the ſmallneſs of the particles that are to be ſeparated. They may likewiſe bear ſome affinity to the configuration of theſe particles, and favour the extraction of them by means of the ſlackening which their folds and various circumvolutions occaſion to the circulation. Thus it is, that by cauſing the aliment to paſs through an infinite number of ſtrainers, nature is enabled to aſſimilate it to the animal, and incorporate it into his fleſh. This is then neither chyle nor blood; it is a much more refined liquor, and known by the vague name of lymph.

We cannot ſufficiently admire the prodigious apparatus of veſſels which perform the ſecretions of diffe-

rent kinds. The kidneys, the liver, the pancreas, &c. are labyrinths in which the moſt conſummate anatomiſt is bewildered. We can only diſcover an inconceivable maſs of white tubes, of an extreme minuteneſs, folded together in thouſands of different ways, which do not admit of any injection, through adhering to the blood-veſſels, and being placed end to end by imagination, would have formed a chain of ſeveral leagues in length. This is all that art has diſcovered in the ſecretory organs. But what a number of intereſting particulars do theſe minute, hollow cylinders contain, which have eſcaped our notice and inſtruments! What varieties ſhould we not diſcover in their ſtructure, functions, and exerciſe, were we permitted to deſcend to the bottom of this abyſs, which conceals from us one of the greateſt myſteries of nature! All the animal liquors are more or leſs mixed, and theſe ſmall tubes no doubt ſufficiently diverſify themſelves to ſeparate the various molecules that muſt neceſſarily enter into the compoſition of every liquor. What then muſt be the ſtructure and fineneſs of thoſe that filtre this ſo ſubtle fluid, compared to æther or light, whoſe operations are diverſified almoſt to infinity!

7. If we knew how a ſingle fibre grows, we could tell how the animal grows; for his whole body is only an aſſemblage of fibres differently formed and combined. Growth always operates by nutrition. This incorporates into the fibre molecules of an heterogeneous nature, which extend in every part. The fibre incorporates into itſelf the heterogeneous molecules according to its own nature. A fibre is not itſelf compoſed of other fibres: theſe of ſtill other fibres: of which there would be no end. But the fibres are formed of molecules or elements, whoſe nature, proportions, and arrangement reſpectively determine the ſpecies of the fibre, and adapt it to ſuch or ſuch a function. Thus the elements of the fibre ultimately effect aſſimilation, which by uniting with the nutritious molecules, that have an affinity with them, give them at the ſame time an arrangement like that which they have in the fibre. The extenſion of the fibre ſuppoſes that its elements

may

may ſeparate more or leſs from each other; but this ſeparation hath its bounds, and theſe bounds are thoſe of the growth. In proportion as the fibre grows, it acquires more ſolidity; for the number of incorporated molecules increaſe every day, ſince it only grows by the ſucceſſive incorporation of molecules of a foreign nature. The more the ſolidity augments, the more the ſuppleneſs diminiſhes. There are more molecules, more coherence, and more attraction under the ſame foldage. The fibre then tends to a ſtate of hardneſs, and the laſt term of its hardening is the laſt term of its growth. When therefore the fibre has acquired its full growth, it is a little organized whole, compoſed of its elementary molecules and of all ſuch as nutrition has incorporated with them during the time of their growth. If then we could ſeparate from the fibre all thoſe molecules which it has aſſimilated, we ſhould reſtore it to its primitive ſtate. This may be applied to all-organized bodies. They are, if we chuſe to term them ſo, net-work. A ſecret force impels the aliment into the meſhes. It increaſes them in bulk, and ſupplies them by little and little. It likewiſe inſinuates itſelf into the elements of the ſolid maſs itſelf. The net-work ſtretches, thickens, and at length becomes hard.

8. We may eaſily comprehend, that all the parts of an animal have ſuch ſtrict and indiſſoluble connexions between them, that they muſt neceſſarily have always co-exiſted together. The arteries imply veins; both of theſe imply nerves; the latter the brain; this the heart; and all of them ſuppoſe a multitude of other organs.

In the germ of a chick there is at firſt perceived a vital point, whoſe conſtant motion attracts the attention of the obſerver. The alternate and quick contractions and dilatation of the living point, ſufficiently indicate that it is the heart. But this heart ſeems to be without any covering, and to be placed on the outſide of the body. Inſtead of appearing in the form of a minute pyramidical maſs, it bears the reſemblance of a ſemi-circle. The other viſcera appear ſucceſſively, and range themſelves after each other, round the living ſpeck.

ſpeck. We cannot as yet diſcover any general folding; all is tranſparent or nearly ſo; and we only perceive by little and little thoſe teguments which are appointed to cover all the parts.

In its firſt beginnings the animal is almoſt entirely fluid. It aſſumes by degrees the conſiſtence of a jelly. All the parts have at that time ſituations, forms, and proportions that differ greatly from thoſe they will afterwards acquire. Their minuteneſs, ſoftneſs, and tranſparency, ſerve to ſtrengthen the illuſion. We perſuade ourſelves that a bowel is naked, becauſe the tranſparency of its coverings prevents our ſeeing them.

Would you have a ſhort and eaſy demonſtration of this? When the lungs of the chick are firſt perceivable, their ſize is but the thouſandth part of an inch. It would have been viſible at the fourth part of theſe dimenſions, were it not endued with the moſt perfect tranſparency. The liver is much greater at its firſt appearance; its tranſparency alone renders it inviſible. It is the ſame with reſpect to the kidnies; whilſt they do not even appear to exiſt, they ſeparate the urine. The heart forces the blood into the arteries ſooner than we could imagine, and it can only be perceived by the growth of the embryo, which is never more accelerated than at the very beginning.

Many other facts concur with theſe to eſtabliſh the pre-exiſtence of organical wholes. We are now ſenſible that many inſects multiply, like plants by ſlips. We cut them into pieces, and each piece regenerates, and becomes a perfect animal. Earth worms are ranked in the number of thoſe inſects that are reproduced from their disjoined parts; and being very large, the phenomena of their re-generation is very perceptible. The piece that is cut off never acquires any growth; it always remains as the ſection left it; only it falls away in a greater or leſſer degree. But after ſome time there appears a very ſmall whitiſh pimple at its extremity, which increaſes by degrees in bulk and length. There are ſoon diſcovered rings, which are at firſt very ſmall and very cloſe. They ſpread themſelves inſenſibly every way. New lungs, a new heart, a new ſtomach diſcloſe themſelves, and with them a number

of

of other organs. This piece, which is newly produced, is extremely ſlender, and altogether diſproportioned to the part on which it grew. We may imagine that we ſee a worm growing, that is grafted at the end of this ſtump, endeavouring to lengthen it. This little vermiform appendage unfolds itſelf ſlowly. At length it equals in thickneſs the piece from which it was cut, and exceeds it in length. It can no longer be diſtinguiſhed from it but by its colour, which is ſomewhat fainter.

Here then is a new organical whole, which grows from an ancient one, and conſtitutes the ſame body; there is an animal ſlip that grows, and expands itſelf on the ſtump of an animal, as a vegetable ſlip does on the trunk of a tree. Remark that the fleſh of the piece cut off does not in the leaſt contribute to the formation of the part regenerated; the ſtump only nouriſhes the bud; it being the ſoil in which the latter vegetates. The part then that is reproduced paſſes through all the degrees of growth, by which the entire animal itſelf had before paſſed. It is a real animal, which pre-exiſted in a very minute form in the great animal that ſerved it for a matrix.

Vegetable productions exhibit to us the ſame conſequences. If a tree be topped, that does not lengthen the trunk of it; but it ſends forth a multitude of buds, in each of which a little tree is comprized; for the bud or branch that ſprings from it is a tree that is grafted on the trunk that nouriſhes it.

Every ſeed in like manner comprizes a plant in miniature. On every ſlight inſpection, we may very eaſily diſcover the ſtalk, leaves, and root of this little plant. But the curious riſe much higher, and diſtinguiſh in a bulbous root or growing bud thoſe flowers that do not blow till the enſuing year.

When the evolution commences in an organized whole, its form differs ſo prodigiouſly from that which it will afterwards aſſume, that we ſhould be apt to miſtake it, were it not to accompany it in all its progreſs. Obſerve how the parts of a plant are folded together, entwined, and concentred in the ſeed or bud. Is this that majeſtic tree which will ere long overſhadow a large

large ſpace of ground? This the flower that will ſo gracefully diſplay itſelf? This the fruit that will aſſume ſuch a regular figure? You can now only perceive an unformed maſs of knotted filaments; yet this little chaos may already contain in it a world, where all is organized and ſymmetrical.

You have ſeen frogs in their firſt ſtate. They appear at that time to conſiſt only of a large head and a long tail. Such is the chick when it begins to expand itſelf. A very ſlender tail, ſtretched in a ſtrait line, is joined to a large head; and the tail contains all the rudiments of the compoſition; nay, is the very compoſition itſelf; and the tranſparent fluid in which it floats, conſtitutes the whole of thoſe ſoft parts with which it is afterwards covered.

The ſame revolutions therefore, which occaſion the heart of the chick to be transformed from its ſemicircular ſhape to that of a pyramid, bring the chick itſelf to a ſtate of perfection. If we were permitted to penetrate to the foundation of the mechaniſm whereby theſe ſucceſſive changes are effected, what a degree of certainty would our knowledge of animal œconomy acquire? We ſhould contemplate in an egg, the myſteries of the two kingdoms. And how greatly would our admiration of that adorable wiſdom be increaſed, which by the ſimpleſt means ever attains the moſt noble ends?

9. Thus the more we aſcend to the origin of organized beings, the more we are perſuaded of their having pre-exiſted before their firſt appearance; not ſuch as they firſt appear to us, but diſguiſed; and were it poſſible for us to trace them ſtill higher, we ſhould undoubtedly find them ſtill more diſguiſed, and ſhould be at a loſs to conceive how they could afterwards acquire that form under which they preſent themſeves to our view.

We can then form no idea of the primitive ſtate of organized beings; that ſtate which I conceive to be given them by the hand of him who has ordained all things from the beginning.

The forms of vegetables and animals, which are ſo elegantly

elegantly varied, are, in the ſyſtem of this admirable pre-ordination, only the laſt reſults of that multitude of ſucceſſive revolutions, they have been liable to, and which perhaps, commenced at their firſt creation. How great would be our aſtoniſhment, could we penetrate into theſe depths and pry into the abyſs! We ſhould there diſcover a world very different from ours, whoſe ſtrange decorations would infinitely embarraſs us. The ſtate, in which we conceive all organized bodies to have been at firſt, is the germ ſtate; and the germ contains in miniature all the parts of the future animal or vegetable. It does not then acquire organs which it had not before: but thoſe organs which did not hitherto appear, begin now to be viſible. We do not know the utmoſt limits of the diviſion of matter; but we ſee that it has been divided in a prodigious degree. From the elephant to the mite, from the globe of the ſun to a globule of light, what an inconceivable multitude of intermediate degrees are there! This animalcule enjoys the light; it penetrates into its eye; it there traces the image of objects; how extremely minute muſt this image be! And how much more minute muſt that of a globule of light be, when ſeveral thouſands, and perhaps millions enter at the ſame time into this eye! But great and ſmall are nothing in themſelves, and have no reality but in our imagination. It is poſſible, that all the germs of the ſame kind were originally joined or linked into each other, and that they are only unfolded from generation to generation, according to that progreſſion which geometry endeavours to aſſign them.

10. A barren egg has a yolk as well as a fruitful egg. And a ray of light has lately ſprung, which has greatly brightened the ſhades in which the myſtery of generation is yet involved.

Beſtow your whole attention on this; you will then diſcover an important truth. A membrane clothes the inſide of the yolk of an egg: and this membrane, which is only a continuation of that which clothes the ſlender inteſtine of the chick is common to the ſtomach, larynx, mouth, ſkin, and epidermis. Another membrane

brane enfolds the yolk externally, and this membrane is only a continuation of that which covers the inteſtine; it unites with the meſentery and peritoneum. The arteries and veins that gently move in the egg, derive their origin from the meſenteric arteries and veins of the embryo. The blood which circulates in the yolk receives the principle of its motion from the heart.

The yolk then is eſſentially a dependance of the inteſtines of the embryo, and together with that compoſes one and the ſame organized whole. So that at its primary period, it is in ſome meaſure an animal with two bodies: the head, trunk, and extremities, compoſe one of theſe bodies; the inteſtines and yolk the other. At the end of the incubation the ſecond body connects with the firſt, and both together form only one.

But ſince the yolk exiſts in eggs that have not been fecundated, it neceſſarily follows that the germ exiſted before fecundation. This conſequence is ſelf-evident: you have lately ſeen that the yolk is an eſſential part of the chick: you have obſerved the ſtrict communication between them. The chick then has never exiſted without it. The membranes and veſſels of the former are only a continuation of the membranes and veſſels of the latter. And what a number of other things are there which are common to both, and which prove that they have never exiſted ſeparately! The chick was then entire in the egg before fecundation. It does not therefore owe its origin to the liquor furniſhed by the cock, but was ſketched in miniature in the egg previous to it. Conſequently the germ belongs ſolely to the female. Such is the grand concluſion which immediately flows from facts.

11. The yolk has its liquors, which are conveyed to it by the arteries belonging to it. They circulate, and without veins there is no circulation. But the arteries and veins of the yolk take their origin from the meſenteric arteries and veins of the fœtus: the heart of this latter therefore is the principle of that circulation which is performed in the yolk. At the time of fecundation the fœtus does not weigh the hundredth part of a grain.

The

The yolk at that time weighs a drachm. It has veſſels proportioned to its ſize. Now if the germ exiſted entire before fecundation, that which we ſtile generation is not the ſame thing with it; but is only the beginning of an evolution, which will by degrees bring to open day ſuch parts as were before hid in impenetrable darkneſs.

But the germ cannot be unfolded in an egg which has not been fecundated, and incubation would only accelerate its eruption. What does it then want to enable it to continue to grow? It has all the organs neceſſary for evolution. It has even already attained to a certain degree of growth, for eggs grow in young pullets; their ovaries contain them of all ſizes. The germ grows there likewiſe. Why cannot it enfold itſelf more than it does? What ſecret force retains it within the limits of inviſibility?

Growth depends on the impulſion of the heart. A greater degree of growth, depends on a greater impulſion. This degree of impulſion, conſequently is wanting in the heart of the germ that has not been fecundated.

This demonſtrates a certain reſiſtance in the parts of the germ. As it grows this reſiſtance augments in proportion. Some reſiſt more than others; the bony parts, or ſuch as will hereafter become ſo, more than the membranous, or thoſe that always muſt remain ſo.

The heart of the germ then hath need of a determinate ſtrength to ſurmount this reſiſtance. Its ſtrength is in its irritability, or in the power it has of contracting itſelf on the touch of ſome liquid. Wherefore to augment the irritability of the heart, is to augment its impulſive force.

Fecundation, without doubt, increaſes this force, and that can alone increaſe it; ſince it is only by the intervention of it that the germ paſſes over the narrow limits that it retained in its firſt ſtate.

12. The fecundating liquor then is a true ſtimulus, which being conveyed to the heart of the germ, excites it in a powerful manner, and communicates to it a new activity. Herein conſiſts what we call conception.

Motion

Motion being once impreſſed on the little moving body, is there preſerved ſolely by the energy of its admirable mechaniſm.

But it is not ſufficient that the heart ſhould acquire a force ſufficient to ſurmount the reſiſtance of ſolids: it is likewiſe neceſſary that the fluid which it conveys to them, and which ſhould nouriſh them, be proportionable to the exceeding fineneſs of the veſſels. Such blood as ours would not circulate in them. The blood of the embryo is at firſt a whitiſh liquor; it grows yellow by degrees, and afterwards red. The more the impulſion of the heart dilates the veſſels, the more groſs, heterogeneous, and colouring particles they admit.

The prolific liquor then is not a mere ſtimulus; but is likewiſe a nutritious fluid appropriated to the extreme delicacy of the germ. It has already diſcharged the functions of a nutritious fluid in the fecundating individual; has cauſed its comb, ſpurs, &c. to grow, and give ſtrength to all his parts.

Being conveyed by the arteries to all the parts, it unites itſelf to the nature of each. From thence proceeds growth, which we do not pay a ſufficient attention to.

It is not long before the chick loſes the firſt form. Wings, thighs, legs, and feet, ſpring out from its long tail. Every thing is formed and diſpoſed on a new model. The little animal, which before was ſtretched out in a ſtrait line, becomes more and more curved. It is ſucceſſively clothed with muſcles, tendons, fleſh, and feathers, and in eighteen or twenty days is a perfect chick.

13. If the chick pre-exiſted in the hen, it is probable the horſe pre exiſted in the mare. This would be more than probable, if it could be demonſtrated that the young of viviparous animals are encloſed in eggs; and that all the difference between viviparous and oviparous may be reduced to this, that the former are hatched in the belly of their mother, and the latter after their iſſuing from it.

On

On the two ſides of viviparous females there is a body reſembling a bunch of grapes, whoſe berries are bladders full of a limpid liquor. Theſe are the ovaries. They communicate with the matrix by two canals which they call tubes. The prolific liquor penetrates into the matrix, and paſſes through the tubes into the ovaries. Thus fecundation is performed. Fœtus's have more than once been found in the ovaries itſelf. Nay more, there has been found in a veſicle of the ovary a complete fœtus ſketched in miniature.

The veſicles of the ovary are real eggs, which after fecundation deſcend through the tubes into the matrix, and are there in ſome meaſure brooded on. In a ſhort time they ſend forth ſmall roots, which convey the nouriſhment to the embryo. The ſuppleneſs of their membranes admits of their extending, and making way for the growth of the little animal. It is true, the growing of eggs is not familiar to us; but the hiſtory of inſects furniſhes us with many examples of it. It even exhibits to us inſects that are at one time viviparous, and another oviparous. The young were in that caſe at firſt lodged in eggs; ſometimes the mother lays her eggs; and at another brings forth living young ones, which were hatched from theſe eggs whilſt they were yet in the matrix.

It is therefore the ſame with reſpect to the veſicle of the ovary, as the eggs of the hen; a germ pre-exiſts in them, but its tranſparency conceals it from us; fecundation renders it viſible.

14. But if an aſs cover a mare, there will be produced from this commerce an animal that will not properly be a horſe, but a mule. Nevertheleſs a horſe was delineated in miniature in the egg of a mare: how then was it transformed into a mule? Whence did it acquire theſe long ears and ſlender tail ſo different from thoſe of the horſe? Diſſection increaſes the difficulty; that informs us that this kind of transformation does not only affect the exterior part of the animal, but the interior likewiſe. The voice of the mule is very like that of the aſs, and does not at all reſemble the neighing of a horſe. The organ of the aſs's voice is an inſtrument that is very much compounded. A drum of a ſingular

a ſingular ſtructure, lodged within the larynx, is the principal part of this inſtrument. This drum does not exiſt in the horſe, but is found in the mule.

The liquor furniſhed by the male conſequently penetrates the germ, ſince it there produces ſuch great changes. But theſe relations of the prolific liquor to the male that furniſhes it muſt neceſſarily depend on the organs that prepare it.

There are then in theſe organs veſſels that ſeparate the molecules relative to different parts of the great whole. Theſe molecules are carried to the correſponding parts of the germ, ſince theſe parts are modified by the action of the prolific liquor. Therefore it incorporates itſelf with the germ, and is the firſt aliment of it, as I ſaid above.

The organs of generation in the aſs have then a relation to his ears and larynx; for they prepare a liquor which modifies the ears and larynx of the little horſe encloſed in the egg. The prolific liquor creates nothing, but it may change what already exiſts. It does not engender the chick, which exiſted before fecundation.

Growth depends on nutrition; the latter, on incorporation. At the ſame time that a part grows, it acquires ſolidity. An exceſs of growth in a part, then, ſuppoſes a ſuper-abundance of nutritious juices, or ſuch as are more active. The exceſſive growth which the ears of the horſe acquire by the influence of the liquor of the aſs, indicates that this liquor contains more molecules, appropriated to the unfolding of the ears, than that of the horſe, or that the molecules of the firſt are more active than thoſe of the ſecond.

The extreme ſoftneſs, I ſhould rather ſay fluidity of the germ, renders every part of it extremely modifiable. Thoſe changes which you cannot conceive in an adult, depend here on the ſlighteſt cauſes.

But if the fecundating liquor modifies the germ, this latter in its turn, modifies the action of that liquor. By virtue of its organization, it tends to preſerve its primitive ſtate, reſiſts more or leſs every new arrangement, and never gives way without always retaining ſomething of its primitive form.

15. Every

15. Every organical production, which has more or leſs parts than the ſpecies requires or conſtructed otherwiſe, is a monſter. The mule, which doth not engender, is therefore a monſter.

The object of inquiry in a celebrated diſpute was, whether certain monſters were ſuch originally or by accident.

It is evident, that the mule is not a monſter from its origin. Monſters do not exhibit ſo much conſtancy and uniformity. Does an egg of which the mule is formed offer itſelf in the ovary of the mare juſt at the inſtant in which the aſs fecundates it?

Two branches, fruits or leaves, graft themſelves accidentally, and afterwards compoſe but one and the ſame whole. Art performs other more extraordinary engraftings, in all of which there is nothing originally monſtrous.

That which happens between two fruits that ingraft themſelves, or are ingrafted by force, may happen in the matrix between two eggs, or in an egg between two germs. Two fœtus's that are united only by the ſpine, perfectly reſemble two fruits that are grafted by contact. An egg ſometimes contains two yolks; conſequently it then contains two germs. How eaſy a matter is it for them to engraft themſelves together as they unfold? We have ſeen a chicken with four feet, which undoubtedly proceeded from a like union. The germs, which are firſt fluid, and for a conſiderable time gelatinous, are very penetrable. If they come in contact, they will mix together in part. Similar organs, which at leaſt half penetrate each other, will ſubſiſt in the other moiety. We ſee clearly this reciprocal penetration in a human fœtus having two heads on a ſingle body. This monſter was evidently formed of two moieties of the fœtus connected together.

If their gelatinous ſtate renders germs very penetrable, it favours with much greater reaſon their union by grafting, or that of ſome parts to each other, either of the ſame germ or two or more germs. The graft is united to its ſubject only by gelatinous or at leaſt by herbaceous fibres. Such fibres are proper for forming new productions, and for connecting and intermingling together.

together. Two polypus's unite together much more eaſily than two rinds; they are abundantly ſofter.

16. Accidental grafts may give birth to monſters which we ſhould term inexplicable, by this principle. But you have not forgot, that all organical parts have forms and ſituations in the germ which differ prodigiouſly from thoſe they will have in the unfolded fœtus. Recal to mind the chick in its firſt form, its heart in that of a ſemi-circle and you will comprehend that thoſe conjunctions which appear impoſſible to you in the fœtus, may be eaſily effected in the germ.

The analogy of parts likewiſe favours their union. This analogy reſults from that of the elements. Two membranes are more diſpoſed to unite than a membrane and a bone; and ſimilar parts of the ſame organ, than parts of different organs.

Laſtly, evolution is not uniform in all parts of the germ: they grow unequally, and this inequality of growth may influence the effects of contact, preſſure, adheſion, &c. Thus a monſter that is produced with ſuperfluous members, may derive them from a germ that has periſhed, and of which only theſe members remained. We plainly ſee how many cauſes may deſtroy ſuch or ſuch a part, and produce a monſter by defect.

But all monſters by exceſs might not owe their origin to the union of two germs. Certain parts may grow exceſſively by the concurrence of particular circumſtances, and augment the number of ſimilar parts in the ſame individual. A ſubject with twenty-ſix ribs is really a monſter by exceſs. It has been proved that ſupernumerary ribs are entirely owing to the unnatural developement of a bony appendage of the tranſverſe apophyſis of one of the vertebræ. The cauſes which operate in the like unfoldings, act nearly as the liquor of the aſs on the ears and larynx of the horſe.

As ſupernumerary ribs unfold themſelves, ſo two or three ribs unite themſelves into a ſingle one, and theſe kind of caſes are not rare either in the vegetable or animal kingdom. Such parts as almoſt touch each other,

are

are very apt to unite: two drops of jelly, and of the ſame jelly, unite very eaſily.

17. The principles I have laid down concerning the generation of animals, are likewiſe applicable to that of plants. What the prolific liquor is to the former, the duſt of the ſtamina is to the latter. There is a wonderful analogy betwixt theſe two claſſes of organized bodies. The ſeed, which ſo nearly reſembles the egg, does therefore in all probability contain a germ, which exiſted in an inviſible manner before fecundation, which makes it ſenſible to us. It appears firſt of all like a greeniſh or yellowiſh ſpeck. It has been thought that a grain of the ſtamina duſt has been perceived in this ſpeck. The germs have on this account been placed in this duſt, and introduced themſelves into the ſeeds, which were deſtined to receive and nouriſh them. But can we diſcover the germ in the egg before fecundation? Notwithſtanding which it pre-exiſts there. It is highly probable that it likewiſe pre-exiſts in the ſeed, and that its minuteneſs together with the tranſparency of its parts, conceals it from our ſight. Will a philoſopher argue, that becauſe a thing is inviſible to us, it does not therefore exiſt?

18. An exact obſerver has taken a good method to clear up the myſtery of the generation of plants. He conſidered what has reſulted from the fecundation of divers ſpecies, by the duſt of different ſpecies. He has ſeen mules that have been well deſcribed proceed from it. Theſe mules, when combined with other ſpecies, have produced new ones. The reſemblances have always been in a direct proportion to the duſt. The changes and alterations have always been ſenſible. The female has had ſome ſuperiority. The privilege of fecundity has adhered more exactly to what came from her, than to that which proceeded from the male. Do not theſe curious obſervations themſelves indicate, that in vegetables, as well as in animals, the germ originally belongs to the female.

CHAP.

CHAP. VIII.

Of Animal Œconomy, considered in Insects.

1. THE ſketch I have lately drawn of animal œconomy, affords a ſlight idea of what conſtitutes the eſſence of life in moſt animals. We ſhall now treat of the principal varieties which the organization of different ſpecies preſents us with. Inſects, hitherto little known, exhibit ſome ſingularities in this very reſpect, to which we ſhall confine ourſelves by way of preference, in order to avoid ſuch details as might carry us too great a length.

We have already ſeen in ſome meaſure the different parts contained in the compoſition of theſe little machines: we will now contemplate their exerciſe and various effects.

2. The mechaniſm of reſpiration is very obſcure in inſects. We only know that in them it differs greatly from that in thoſe animals which are moſt known to us. But we judge with greater certainty concerning this difference by the compariſon of the organs, than by that of their exerciſe. When a drop of greaſy liquor is applied to one or ſeveral ſtigmata of an inſect, the correſponding parts become paralytic. The interception of the air in one part is followed by that of liquors or ſpirits. When we ſtop up all the ſtigmata, the inſect dies immediately. If we afterwards open them, we ſhall perceive the inſide to revive. The air which then penetrates the open orifices of the tracheæ, evidently produces this kind of reſurrection.

The

The tracheæ or air-veſſels are divided and ſubdivided in a prodigious degree. May they not reſemble ſo many ſieves, which by ſeparations ſuitably contrived, are capable of furniſhing to each part an air of a more or leſs ſubtle nature, as occaſion requires? There are commonly reckoned to be nine ſtigmata on each ſide of the body: but ſometimes they are more in number, at others, fewer. The ſame inſect has ſome that are of greater or leſs importance to it, or whoſe functions are more or leſs neceſſary. In ſeveral ſpecies, the principal ſtigmata are placed behind: in others at the head. Inſtead of ſtigmata, they are pretty frequently obſerved to have little tubes of different lengths.

3. The circulation of the blood is performed in inſects with great regularity. We trace it by our ſight, in ſome ſpecies of long and tranſparent worms. We may ſee the heart, or principal artery, contract and dilate itſelf ſucceſſively in every part of its extent. It ſeems to be compoſed of a great number of little hearts, placed end to end, that tranſmit the blood to each other.

We are yet ignorant in what manner the blood is conveyed into the grand artery. Its principal ramifications, and the canals analogous to veins are equally unknown. We are only certain, that in many ſpecies, for the moſt part of the creeping ſort, the principle of circulation is towards the hinder part, whereas in others it is towards the head. It is very probable that the grand artery ſhoots forth, from both ſides of it, ſeveral branches that are inviſible, by reaſon of their extreme fineneſs or tranſparency, and that diſtribute the blood to every part. Other branches are without doubt connected with them, and conduct the reſidue of the blood to the principal trunk of veins, which is imagined to be perceived on the oppoſite ſide of the heart. The blood of inſects is a ſubtle liquor tranſparent, commonly without colour, and though it be not in the leaſt inflammable, reſiſts, in ſome ſpecies, a degree of cold ſuperior to that of our ſevereſt winters.

4. The organs of generation, in moſt inſects, are placed at the extremity of the belly. That which characteriſes the male, conſiſts principally of one or two ſpecies of fleſhy horns, which are turned different ways, and are generally drawn within the body, but emitted from thence at the pleaſure of the inſect. The hind parts of divers males is alſo furniſhed with hooks, by means of which they faſten on that of the females. In the interior part are lodged different veſſels, which are connected with the principal organ of generation, and ſeparate the fecundating liquor from the maſs of blood. At the end of the aperture formed in the female, there is joined a kind of canal, which, in many inſects, ſends forth ſeveral branches, called tubes or ovaries. Theſe are ſpecies of very fine inteſtines, in which the eggs are ranged in a row, almoſt like the beads of a chaplet.

The eggs neareſt the aperture are the largeſt, or in a more advanced ſtate. They gradually diminiſh according to their diſtance. At length they become altogether inviſible.

In the common paſſage, where the ovaries terminate, there is inſerted, in ſome ſpecies, a very ſhort canal, which communicates with an oblong cavity, that is conſidered as analogous to the matrix. In this cavity the liquor of the male is depoſited.

Amongſt viviparous animals the œconomy of the tubes changes. Sometimes the young are ranged in bunches. At others they form a kind of cord twiſted ſpirally, whoſe length, width, and thickneſs exactly correſpond in number to the length and thickneſs of the young that compoſe it. The young of ſome viviparous inſects, before they are brought forth, tear the membrane or ovary that encloſes them; they are, to uſe the expreſſion on this account ſubject to a two-fold birth.

The eggs of inſects are of two kinds: ſome are membraneous, like thoſe of tortoiſes and reptiles: others are cruſtaceous, as are theſe of birds. But whereas in large animals the ſpecies comprized under theſe genera differ only from each other by a ſlender variety; amongſt inſects theſe varieties are ſo great, that one animal

animal does not differ more from another, than one of their eggs does from another. Some of them are round, elliptical, lenticular, cylindrical, pyramidical, flat. Some are quite ſmooth, others grooved or channelled. In ſhort, what is more extraordinary, there are ſome eggs that grow after they are laid. We eaſily judge that they are entirely membranous. The ſuppleneſs of their membranes admits of their extenſion. They have pores that imbibe the juices of the plant where they are depoſited. Theſe are minute placentiæ that tranſmit the nouriſhment to the embryo.

5. The diſtinction of inſects into viviparous and oviparous does not only take place in ſpecies of different claſſes, but likewiſe in ſpecies of the ſame germs. There are ſome two-winged flies that are viviparous, and others that are oviparous.

Add to this, that ſome ſpecies are viviparous at one time, and oviparous at another. The vine-fretter furniſhes an example of this.

All great animals that are known to us, are diſtinguiſhed into males and females, and propagate the ſpecies by copulation. The ſame order prevails amongſt inſects; but all the ſpecies are not ſubject to it, and, of thoſe that are, ſeveral afford us ſome very remarkable ſingularities. In divers ſpecies, the male is winged, and the female not. The glow-worm which is ſentenced to crawl during its whole life time, is fecundated by an inſect having four wings.

Sometimes this ſtriking ſingularity is joined with others that are ſtill more ſurpriſing. Every where elſe we obſerve a certain proportion betwixt the male and female; here this proportion vaniſhes entirely. The female is a coloſſus, on which the male walks as on a ſpacious ſpot. The ardor and agility of the male are exceſſive. He is almoſt in continual motion. The female on the contrary, moves but ſeldom, and that heavily. She ſometimes ſpends the greateſt part of her life in the moſt perfect inactivity. In fine, the male is an inſect properly ſo called, his whole body is interſected by inciſions that are very conſpicuous: the female is a ſpherical maſs, fixed to a branch, that one

would be apt to take for an excreſcence or gall nut of this branch. You will imagine that I am ſpeaking of gall-inſects, whoſe name ſo well explains their deceitful appearances. They are found in great numbers on the branches of many trees and ſhrubs. They are greatly diverſified; but always affect the form of gall-nuts more or leſs round. They imbibe the juice of the tree by the aſſiſtance of a little pump, which they keep fixed to the bark. They lay ſome thouſands of eggs, which are piled up under the mother's belly, as they iſſue from it. When the whole number is laid, the gall-inſect dies, and its carcaſe remains faſtened to the branch. This is only a cod full of eggs, which one might ſtill take for a living gall-inſect, ſo ſmall an appearance of life is there in this ſtrange animal. The young are hatched in a ſhort time, when there immediately appears a multitude of very ſmall animated membranes, either oval or circular, which are borne on ſix legs, and diſperſe themſelves on all ſides with a wonderful celerity.

6. Several of the ſpecies that live in ſociety, preſent us with three ſorts of individuals; to wit, males, females, and neuters, or individuals that remain always deprived of ſex. This we obſerve in the republics of bees, waſps, and ants. We know that each ſwarm of bees has but one female, which bears the name of queen; the males which are called drones, pretty often amount to four or five hundred; the neutres which are much morenumerous, are ſometimes forty or fifty thouſand in number. Theſe are the helotes of the little ſparta; they are charged with all the labour. The queen and drone are wholly taken up in furniſhing the ſtate with citizens. She is in a literal ſenſe the mother of all her people; ſhe lays in one year upwards of fifty thouſand eggs. She produces three ſorts of them, from whence are hatched three kinds of individuals of different ſhape. The neuters then conſtruct three ſorts of cells, to receive the eggs, and lodge the young to be hatched from them.

Divers ſpecies of inſects are real hermaphrodites; in each individual both ſexes are united, but he cannot

fecundate

fecundate himſelf ; and generation depends in this caſe as elſewhere, on the concurrence of two individuals.

7. Other inſects are hermaphrodites of a more ſingular nature ; each individual propagates without any commerce with another. We have the firſt example of this in the vine-fretter, that deſerves ſome attention.

You have very frequently ſeen little flies faſtened in a great number to the extremities and leaves of plants, and twiſting them round in various forms : theſe are vine fretters, whoſe ſpecies are almoſt as numerous as thoſe of vegetables, and whoſe remarkable properties are multiplied in proportion to the attention we pay them.

They bring forth living young ones. Their births are eaſy to trace, there needs only good eyes and a little patience. Take up a little one as ſoon as it is produced : encloſe it immediately in the moſt perfect ſolitude, and in order to be the better aſſured, carry your precautions to a degree of ſcrupulouſneſs ; be with reſpect to it a more vigilant Argus than the fabulous one. When the little recluſe has acquired a certain growth, it will begin to have young, and after ſome days you will find it in the midſt of a numerous family.

Make the ſame experiment on one of the individuals of this family that you have tried on its chief : the new hermit will multiply like its father, and this ſecond generation brought up in ſolitude will not prove leſs fruitful than the firſt.

Repeat the experiment from one generation to another ; abate nothing of your cares, your precautions, ſuſpicions ; proceed, if your patience will permit you, to the ninth generations, and they will all preſent you with fecund virgins.

After theſe experiments, ſo deciſive and reiterated, you are eaſily perſuaded that there is no diſtinction of ſex in vine-fretters. What indeed would be the uſe of ſuch a difference amongſt a people where all the individuals are conſtantly ſufficient for themſelves? Natural hiſtory is the beſt logic, becauſe it beſt teaches us to ſuſpend our judgment. Vine-fretters are really diſtinguiſhed

by ſexes; there are males and females amongſt them, and their amours are the leaſt equivocal of any in the world. I do not know whether there are in nature any males more amorous than they.

What then is the uſe of coupling between inſects that multiply without its aſſiſtance? of what ſervice can an actual diſtinction of ſex be to real androgynes? The clearing up of this point depends on another great ſingularity. During the ſummer ſeaſon they are viviparous; they all bring forth living young. Towards the middle of autumn they become oviparous; they all then lay real eggs which are hatched at the return of the ſpring. The males begin to appear exactly at the time the females begin to lay. There is therefore a ſecret relation betwixt the appearance of the males, and the laying of the females. There are always found in the bodies of the females, eggs and young ready to be produced. The young then were originally encloſed in eggs. During the fine ſeaſon, they are hatched in the belly of their mother, and are brought into the world alive. Plants at that time furniſh them with a proper nouriſhment, which they fail not inſtantly to imbibe by the help of a very ſlender trunk. At the approach of cold weather, the young cannot unfold themſelves in the dam's belly, in order to their being produced alive; they remain ſhut up in their eggs, where they are preſerved the whole winter. Were they to be hatched at the beginning of that ſeaſon, they would ſoon periſh for want of food. The developement depends ultimately on nutrition. Vine-fretters that are produced alive, are more unfolded in the matrix than thoſe which are brought forth encloſed in eggs. The former then have received a nouriſhment in the matrix, which the others were not able to obtain there. This nouriſhment was ſufficient to effectuate the entire opening of the germs. Had not coupling, then, for its primary end, the ſupplying the defect of this nouriſhment in ſuch germs as were not to be hatched till after they had iſſued from the belly of their mother?

I have treated of ſome ſpecies of inſects, the males of which are winged, and the females not. This ſingularity

gularity is alſo to be met with amongſt vine-fretters; but they offer ſtill more to us with reſpect to this. Some of the males are winged, and others remain their whole life-time without wings. There are likewiſe winged females, and other females that are not. But this is not all: the males, and particularly thoſe that are deſtitute of wings, are ſo ſmall in compariſon of the females, that they are ſeen to walk upon them as a mite upon fruit; to ſo great a degree has nature thought fit to abound, with regard to theſe inſects, in ſingularities of different kinds.

8. Animals that multiply by ſlips and ſhoots, and that may be grafted, appear to be real zoophytes, or plant-animals.

Of theſe ſome have feet or members, others not. We will firſt treat of the latter ſort.

The ſlime which covers the botttom of ponds and marſhes, may almoſt be deemed a reſpectable thing; there the great Being has not diſdained to aſſemble the traces of his power and wiſdom. He has connected the exiſtence of this vile matter with that of different ſpecies of worms that are deſtined to live in and feed upon it, and that will one time or other preſent us with the intereſting ſight of a new reproduction, which we ſhall never think we can ſufficiently admire, and ſhall therefore wonder at it in proportion as our underſtanding is enlightened.

All theſe worms are long and ſlender. They are not unlike the treble ſtring of a violin: their body is formed of the ſucceſſion of a great number of little rings, which decreaſe gradually as they approach the extremities. They are very ſoft: their head, which terminates in a blunt point, is ſuſceptible of various motions. It contracts, dilates, lengthens, and ſhortens itſelf at the pleaſure of the inſects. The mouth is furniſhed with a muſcle that directs the functions of it, and whoſe exerciſe is pretty perceivable. The anus, which is placed at the oppoſite extremity, is a little oblong aperture, bordered with an analogous muſcle. The whole ſkin is ſo tranſparent, as to admit of its being inſpected within, and we may congratulate ourſelves on this circumſtance, ſince it affords us a great

ſpectacle

ſpectacle. The polypus exhibits nothing that has the appearance of the viſcera. All its ſubſtance ſeems to be compoſed of a maſs of ſmall ſimilar ſeeds. Our fiddle-ſtrings are minute beings, quite differently organized, and the apparatus of the viſcera, which the microſcope diſcovers to us, ſeems to advance them far above the polypus. A long veſſel that goes winding from the head to the tail, is what chiefly ſtrikes the eye of the obſerver. By its regular alternate motions, he will ſoon know it to be the heart or grand artery. The liquor that circulates in theſe winding paſſages is limpid. It is perceived from the pulſations it excites in every part of the artery comprized betwixt two of the rings. One would be apt to imagine each of theſe portions to be a real heart, and that every artery was a chain of little hearts, placed end to end, and that forced the blood from one part to another. It is ſeen to run with an uniform motion through all theſe little hearts, and riſes in this manner, as by ſo many bladders from the tail to the head, near which it finally diſappears. In different parts of the artery are diſcovered delicate ramifications of veſſels, which may be taken for veins, there being perceived no pulſation in them. Beneath and along the artery there is a canal, whoſe diameter varies at different points of its extent. It is the inteſtinal duct, which comprehends the œſophagus, ſtomach, and inteſtines. The aliment is there ſeen to digeſt before the eyes of the obſerver: he follows it in his paſſage: ſees it deſcend from the mouth towards the anus, and paſs through every part of the canal between theſe two extremities. But can machines ſo compounded as theſe be taken to pieces without injuring their œconomy thereby?

That ſuffers not in any reſpect on that account. Strictly ſpeaking it affects theſe inſects no more than being divided in the midſt of the body. Each half not only continues to live and move: but that which had no head preſently forms another, and we may clearly perceive a new tail ſpring forth in that part which was deſtitute of one. In leſs than three days the two moieties become two complete worms.

It is more extraordinary for fourths, eighths, and ſixteenth parts of our worms to aſſume a head and tail: this is ſo ſpeedily effected, that in a few days all theſe fragments are ſo many perfect inſects, and after a few weeks attain to the ſame length as the entire worm. New rings and new viſcera unfold themſelves, the parts reproduced differ in no reſpect from the ancient ones. Thus the machine is formed anew by its own ſtrength; and the ſection, which might be a means of deſtroying them, ſerves only to make them conſpicuous.

I have not yet ſufficiently treated of this particular. The ſix and twentieth part of worms, to wit, perfect atoms, are able to re-integrate themſelves extremely well, and in the ſpace of ſome months are found to be worms of ſeveral inches in length. In theſe living atoms, as well as in the moſt conſiderable fragments, the circulation ſeems to be performed with the ſame regularity as in the whole worm. Each atom has its little heart, and we may clearly perceive that this little heart is no other than a very ſmall portion of the grand artery of the worm, whereof the atom was before a part.

We may weary ourſelves in cutting the head off the ſame individual: we ſhall have the ſame taſk to repeat continually, becauſe there always ſhoots forth a new one. We may even cauſe ſeveral to iſſue at the ſame time, each of which ſhall have their proper functions.

There is another ſpecies of theſe worms, amongſt which the property of becoming again entire is confined in very remarkable bounds. It forms a head or tail in the middle; but if it be cut into three or four parts, the intermediate ones puſh forth a tail where a head ſhould have been produced. This ſupernumerary tail, which is in no reſpect deficient, cannot perform the office of a head, and the unhappy inſect is condemned to periſh with hunger.

9. Look into this rivulet, whoſe bottom is covered with broken pieces of plants: what do you perceive upon them! Spots of mouldineſs. Do not miſtake: this mouldineſs is not what it appears to be: and you already begin to ſuſpect ſo: you think that you great-

ly ennoble them by advancing them to the rank of vegetables: you conjecture they are plants in miniature, that have their flowers and ſeeds, and plume yourſelf on being able to judge of theſe mouldineſſes in a different manner from the vulgar. Take a magnifying glaſs: what do you diſcover? Some very pretty noſegays, all the flowers of which are in bells. Each bell is ſupported by a ſmall ſtalk, which is implanted in a common one; you now no longer doubt of the truth of your conjecture, and cannot be perſuaded to quit this microſcopic parterre. You have not however ſufficiently obſerved it. Look ſtedfaſtly on the aperture of one of theſe bells: you will there perceive a very rapid motion, which you cannot be weary of contemplating, and which you compare to that of a mill. This motion excites little currents in the water, that convey towards the bell a multitude of corpuſcles, which it ſwallows up. You begin to doubt whether theſe bells are real flowers; and the motions of the ſtalks which appear to be ſpontaneous, increaſe your ſuſpicions. Continue your obſervations: nature herſelf will teach you what you ought to think of this ſingular production, and will furniſh you with freſh motives for admiring the fecundity of her ways. That is a bell which detaches itſelf from the cluſter, and that floats along in order to fix itſelf to ſome ſupport. Follow it. A ſhort pedicle iſſues from its extremity: and the bell faſtens itſelf by the end of this pedicle. It lengthens and becomes a little ſtalk. It is no longer a noſegay you are beholding, it is a ſingle flower. Redouble your attention; you are juſt arrived at the moſt intereſting moment of inſpection. The flower is cloſed, has loſt its form of a bell, and aſſumes that of a bud. You perhaps ſuſpect that this bud is ſome fruit, or a ſeed that has ſucceeded to the flower: for you are loth to give up your firſt conjecture. Do not loſe ſight of this bud; it is now divided by degrees according to its length, and the ſtalk is at preſent ſupplied with two buds, leſs than the firſt. Examine what paſſes in both of them. They widen themſelves inſenſibly, and you perceive a motion at the edge of the opening, which increaſes in ſwiftneſs in proportion as the bud unfolds

itſelf.

itſelf. The mill appears again, and the two buds have aſſumed the form of a bell. Can a fruit, which changes into flowers, be a real fruit? Can ſuch flowers be real flowers, that ſwallow little inſects? Suſpend your obſervations, and repeat them a few hours hence. Your flowers are cloſed up as the firſt was; you eaſily gueſs that they will ſeparate themſelves as before, afterwards open, and preſent you with four bells. That is already effected, and you have a little noſegay, compoſed of four flowers. If you continue your inſpection, you will ſee them augment in bulk by new diviſions into two's, and ſoon after you will count ſixteen, thirty-two, ſixty-four flowers. Such is the origin of this microſcopical parterre, which at firſt drew your attention: how much more admirable does it now appear than you then conceived it to be! What a group of wonders does a ſingle ſpot of mouldineſs afford! What unforeſeen, varied, and intereſting ſcenes, are tranſacted on a ſcrap of rotten wood! What a theatre does it exhibit to a thinking being! But our abode is ſo recluſe, that we have but a glimmering view of it; how great would our raviſhment be, if the whole ſpectacle diſcloſing itſelf at once to us, we ſhould be enabled to penetrate into the interior ſtructure of this wonderful aſſemblage of living atoms! Our blunted eyes diſcover only the moſt ſtriking parts of them; they only apprehend the groſs parts of the decorations, whilſt the machines that execute them remain concealed in impenetrable darkneſs? Who ſhall enlighten this profound obſcurity? Who ſhall dive into this abyſs where reaſon itſelf is loſt! Who draw from thence the treaſures of wiſdom and knowledge concealed within it? Let us learn to be content with the ſmall portion communicated to us, and contemplate with gratitude thoſe firſt traces of human underſtanding imparted to us, towards a world placed at ſuch a great diſtance from us.

10. You cannot quit this ſpring, from whence you have derived ſo many truths, that are ſo aſtoniſhing. You diſcover in it other microſcopical animals, whoſe form reſembles that of a funnel. Theſe are likewiſe

polypus's.

polypus's. They do not compoſe a cluſter ; but cleave to ſomebody by their inferior extremity ; you are curious to know their method of multiplying. In order to this, place your microſcope on one of theſe funnels. Of a ſingle funnel, there are formed two by a natural diviſion ; but very different from that of bell polypuſes ; ſo far has nature thought fit to vary her proceedings with reſpect to theſe animals. Examine what paſſes in the middle of the funnel. A tranſverſe and oblique ſtripe indicates to you the part where the polypus is about to divide itſelf. The diviſion then is made ſlopingly. The ſtripe points out the edges of the new funnel, and theſe are only the lips of the freſh polypus. You diſcover in them a pretty ſlow motion, which helps you to diſcern them. They approach each other inſenſibly, the body collects itſelf by degrees ; a little ſwelling forms itſelf on the ſide, which is a new head. You already clearly diſtinguiſh two polypus's placed above each other. The upper polypus has the former head and a new tail ; the inferior one a new head and the former tail. The upper polypus is connected with the other only by its lower extremity. By a motion it gives itſelf, it is at laſt detached from the other ; and floats away in order to fix elſewhere. The inferior polypus remains faſtened to the place where the funnel was before the diviſion.

11. Net polypus's likewiſe derive their name from the exterior form of their bodies ; they pretty nearly reſemble that of a fiſhing-net. They aſſemble in groups, and faſten on all the bodies they meet with in freſh water. They are very tranſparent. In the inſide of the polypus there is formed an oblong and whitiſh body. As ſoon as it is formed, it deſcends by degrees, ſhews itſelf on the outſide, and remains fixed perpendicularly on the polypus. It produces new ones every day ; and the group they compoſe on the exterior part of the polypus, increaſes in growth. If theſe minute bodies be eggs, they are of a ſingular ſpecies ; they are abſolutely without any covering, and are neither membraneous or cruſtaceous. We cannot affirm of theſe eggs, that young are hatched from them, but are

under

under a neceſſity of acknowledging, that theſe little oviform bodies unfold themſelves. This developement is accompliſhed in a few minutes, and the polypus becomes the ſame as its mother: imagine to yourſelf a bird that ſhould iſſue from its mother's belly, entirely naked, rolled together like a ball, whoſe members ſhould afterwards diſplay themſelves, and you will have a repreſentation of the production of net polypuſes.

12. Cluſter-polypuſes propagate by dividing in the middle; arm-polypuſes do not multiply in this manner. They bring forth their young almoſt as a tree ſhoots forth its branches. A little bud appears on the ſide of the polypus. Do not ſuppoſe that this bud contains a polypus, as the vegetable bud comprizes a branch: it is itſelf the polypus in its growth. It increaſes in ſize and length, and at laſt ſeparates from its mother. Whilſt it is united to her, they both compoſe one body, as the branch with the tree. You are to underſtand this in the ſtricteſt ſenſe. The prey which the mother ſwallows, paſſes immediately into her young, and imparts the ſame colour to it. So that the whole conſiſts of one little bowel in a great extent. The prey which the young one ſeizes (for it fiſhes for it as ſoon as it has arms) paſſes in like manner into the mother. They nouriſh each other reciprocally.

There is ſcarcely any polypus without buds. All of them therefore are ſo many polypuſes, or ſo many ſhoots that grow on a common trunk. Whilſt they are unfolding, they themſelves ſend forth ſmaller ſhoots, and theſe ſmaller ſtill. They all extend their arms on both ſides. You think you are beholding a very buſhy tree. The nouriſhment received by one of theſe ſhoots, is ſoon communicated to all the reſt, and to their common mother; the chief of the ſociety and the members are one. The ſociety is diſſolved by little and little, the members ſeparate themſelves, are diſperſed, and each ſhoot becomes in its turn a little genealogical tree.

Such is the natural method by which the arm-polypus multiplies. It may alſo be multiplied by ſlips.

There

There is no need to mention, that when it is cut in pieces, each piece in a ſhort time becomes a perfect polypus. It were better to ſay at once, that the polypus, after being cut into ſmall pieces, riſes again from its ruins, and the little fragments yield as many polypuſes. Being cut either in length or width, this extraordinary animal is reproduced in the ſame manner, and the ſources of life are equally inexhauſtible.

13. But the following is what fable itſelf has not preſumed to invent: bring to their trunk the heads that have been ſtruck off, they will reunite to it, and you will reſtore to the polypus its head. You may alſo, if you think proper affix to it the head of another polypus. The mutilated parts of the ſame or different polypuſes, when placed end to end, will unite in like manner, and form only a ſingle polypus.

What have I hitherto ſaid? There is ſcarce any miracle that may not be performed by means of the polypus; but miracles, when multiplied to ſo great a degree, hardly appear to be ſuch. A polypus may be introduced by its hind part into the body of another polypus. The two individuals unite, their heads become ingrafted into each other; and the polypus, which at firſt was double, is converted into a ſingle polypus, that eats, grows and multiplies.

I have compared the polypus to the finger of a glove: this finger may be turned inſide out: ſo may the polypus likewiſe, and being ſo ſhifted, can fiſh, ſwallow, and multiply by ſlips and ſhoots.

It will be eaſily believed that the polypus does not like to remain thus ſhifted. It makes an effort to regain its former poſition, and frequently ſucceeds either in part, or altogether. The polypus, which is partly turned back again as at firſt is a real Proteus, that aſſumes all kinds of forms, which are all equally ſtrange. Endeavour to repreſent to yourſelf the polypus thus turned again. You remember that the inſect is made in the form of a bowel. One part of the bowel then is turned backwards on the other; it there faſtens and engrafts itſelf. In that caſe the polypus is as it were doubled. The mouth encompaſſes the body

like

like a fringed girdle ; the arms are the fringe. They then point towards the tail. The fore-part continues open ; the other is uſually ſhut up. You expect no doubt to ſee a new head and new arms to grow out of the fore-part ; which you have obſerved in all the polypuſes that have been divided tranſverſely. But the polypus combines itſelf a thouſand different ways, and each combination has its conſequences, which experience alone can diſcover to you. The fore-part cloſes itſelf ; it becomes a ſupernumerary tail. The polypus, which was at firſt extended in the right line, is curved more and more. The ſupernumerary tail lengthens every day. The two tails reſemble the feet of a pair of compaſſes. The compaſſes are partly open. The ancient mouth is at the head of the compaſſes. This mouth, which is faſtened to the body, and embraces it like a ring, cannot diſcharge its functions. What then muſt become of the unfortunate polypus with two tails and without a head ? How will it be able to live ? Do you think that you have taken nature at unawares ? You are miſtaken. Towards the upper part of the polypus, near the ancient lip, there are forming not only a ſingle mouth, but ſeveral ; and this polypus, concerning which you inquired a minute ago how it could exiſt, is now a ſpecies of hydra with ſeveral heads and mouths, and devours with all theſe mouths.

14. What a multitude of phyſiological truths, that were unknown to us in the vegetable kingdom, has the arm-polypus alone unveiled to us ? How do theſe truths appear as paradoxes, and yet how evidently are they demonſtrated ? Who can doubt now that there exiſts an animal, a very animal, ſince it is extremely voracious, whoſe young grows like branches, and which being cut to pieces and actually minced, regenerates anew in all its parts, and even in the ſmalleſt fragments, that may be grated by approximation or inoculation, turned inſide outwards like a glove, afterwards cut, turned back and cut again, without ceaſing, to live, devour, grow, and multiply.

It was not a fit ſeaſon therefore to make general rules, to arrange nature, eſtabliſh diſtributions, form ſyſtematical orders, and to raiſe an edifice, which future ages, better inſtructed, will even dread to project. We have ſcarce any knowledge of the animal, when we would undertake to define it. Becauſe our knowledge is at preſent in ſome meaſure improved, ſhall we preſume to think we thoroughly know it? Polypuſes have aſtoniſhed us, becauſe on their firſt appearance there was no idea in our brain analogous to them, and we had taken great pains to diſcard from it the very poſſibility of their exiſtence. How many animals are there that are even more ſtrange than polypuſes, and that would confound all our reaſonings, could we diſcover them? It would be neceſſary on that occaſion to invent a new language, in order to deſcribe our obſervations. Polypuſes are placed on the frontiers of another univerſe, that will one time or other have its Columbus's and Veſputiuſes. Shall we imagine that we have penetrated into the interior parts of the continents, becauſe we have taken a ſlight view of ſome coaſts at at diſtance? We will form to ourſelves more exalted ideas of nature; we will conſider her as one immenſe whole, and will firmly perſuade ourſelves that what we diſcover of her is but the ſmalleſt part of what ſhe contains. Having been heretofore aſtoniſhed, we will forbear being ſo for the time to come, but will continue our obſervations; we will amaſs freſh truths, connect them if we are able, and be in expectation of every diſcovery, becauſe we will continually ſay, that the known cannot ſerve as a model for the unknown, and that models have been varied ad infinitum. Cluſter-polypuſes multiply by dividing themſelves; who can tell but that there may one time or other be diſcovered animals, that inſtead of dividing themſelves, may unite together, and join themſelves to one another, in order to compoſe one ſingle animal? Or who knows whether the multiplication of ſuch an animal may not have as an eſſential condition, the conſolidation of ſeveral animalcules in a ſingle one? We ſay that an animal muſt have a brain, a heart, arteries, veins, nerves, a ſtomach, &c. Theſe are the ideas we have deduced

from

from large animals, and we carry them every where with confidence. We act herein like a French traveller, who ſhould expect to find in the Terræ Auſtrales the modes of his own country, and that would be greatly chagrined on being diſappointed. The animal kingdom has alſo its Terræ Auſtrales, in which probably it is not cuſtomary to meet with a brain, a heart, a ſtomach, &c. Why do we deſire that nature ſhould always condeſcend to form one animal with the elements of another? She might indeed be conſtrained ſo to do, did not her fecundity ſurpaſs that of our poor conceptions? But the hand, which has formed the polypus, has demonſtrated to us, that it can, when neceſſity requires, animalize matter at a much leſs expenſe. It has deſcended by almoſt inſenſible degrees from thoſe great organized maſſes we call quadrupeds, to thoſe minute organized bodies we ſtile inſect; and by gradual and ſkilfully contrived ſubtractions, it has at length reduced animality to her ſmalleſt terms. We are unacquainted with theſe ſmalleſt terms. The polypus, ſimple as it appears to be, is without doubt very much compounded, in comparison of ſuch animals as are placed beneath it in the ſcale. It is, if we may be allowed the expreſſion, too much an animal, to be the laſt term of animality. We know that the brain is the principle of the nerves, that it filtres the ſpirits; that the nerves are the organ of feeling; that the heart is the primum mobile of circulation; that the veins and arteries are the dependancies, all this we have ſeen in great animals, we have again to our ſurpriſe found it in inſects: though under different forms: we were thus accuſtomed to regard theſe various organs, and ſome others, as eſſential to the animal. The polypus, however, exhibits to us nothing ſimilar; the beſt microſcopes only diſcover to us an infinite number of ſmall diſſeminated ſeeds in its whole ſubſtance; and the unforeſeen experiment of its ſhifting, ſufficiently proves that there is nothing in its ſtructure common to that of animals before known to us. Were we not capable of imagining, that an animal had been endued with the property of being propagated and grafted like a plant, it would have been much leſs poſſible for us to ſuſpect that there had been granted to it the power

of

to ſuſpect that there had been granted to it the power of being turned inſide out like a glove. The arm-polypus, is nevertheleſs a perfect animal; its voracity is exceſſive; it devours all the little inſects that happen to touch it, and ſeizes them with ſuch ſkill, as ſeems to give it an affinity to hunting animals. The cluſter-polypus quite differently conſtructed, has not the ſame advantages, but has relative ones: it can excite a rapid motion in the water which brings towar- it thoſe living corpuſcles it feeds upon. There are undoubtedly many animals that are ſtill much more diſguiſed than the cluſter-polypus, and by not affording us any exterior ſign of animality, leave us for a long time uncertain of their true nature. When a bulb of ſuch a polypus is detached from it, and fixes it by its ſhort pedicle to any ſupport, ſhould we be apt to conſider it as an animal production: has not the gall-inſect been taken for a real vegetable gall-nut by ſuch obſervers as had not ſeen it in its primitive ſtate? Is not the pond muſcle deficient in many things we judge to be neceſſary for the animal? How many ſhell-fiſh are ſtill farther degraded? Nay more, there may probably exiſt ſome animals, which it would be impoſſible for us to acknowledge as ſuch, even though their whole ſtructure, as well internal as external, ſhould be laid open to us; the reaſon is, that judging only according to our preſent notions, we cannot deduce from this ſtructure the opinion of life.

15. I cannot yet quit this ſubject. We are not able to conceive all the methods by which the author of nature has given life and ſenſation to a prodigious number of different beings. Let us judge of them at leaſt by a compariſon of a ſmall number of animated beings we are acquainted with. How greatly does life differ in the ape and bell-polypus? What intermediate degrees are there betwixt theſe two terms? Perhaps there are ſtill more from this polypus to the laſt of animals. I do not examine if ſouls have been varied like bodies; but I conceive that organized matter has been modified infinite ways, to which have correſponded as many different

different methods of participating life and ſenſation. I likewiſe conceive that the ſame ſoul, if placed ſucceſſively in all the organized bodies that exiſt, would ſucceſſively experience all the poſſible modifications of life and ſenſibility. This ſoul would paſs through all the degrees of animality; and if ſhe could remember them all, and compare them, ſhe would equal the ſuperior intelligences in knowledge. She would contemplate our world through all thoſe glaſſes that have been given to the various beings that inhabit it.

16. Let us draw a general conſequence from all this: that analogy, which is one of the great lights of phyſics, is not capable of diſſipating the ſhades of it. This light is frequently extinguiſhed on the approach of certain bodies which we bring to the touch of experiment. To what purpoſe does analogy ſerve in the examination of the bulb-polypus? We cannot even define theſe bulbs; and does the name we give them expreſs any thing more than mere appearances? How can analogy enlighten us concerning the nature of theſe minute bodies, and the manner by which they are engendered and ingender, whilſt ſhe offers nothing to us either in the vegetable or animal kingdom, which bears the leaſt relation to theſe productions, ſo different from all thoſe that were known to us? I affirm as much with regard to the natural diviſion of the bells, and of the ſhifting of the arm-polypuſes. This is an entire new order of things, which has its particular laws, which we ſhould in all probability be able to diſcover, could we find ſome means of penetrating into the ſecret mechaniſm of theſe little beings. We ſhould then diſcern all the ſides by which they are connected with other parts of the organical world.

17. When we conſider in a general view the compoſition of men and quadrupeds, we ſhall preſently diſcern that there is with reſpect to all of them the ſame foundation of ſtructure, differently modified in different ſpecies. In order to be convinced of this, we need only caſt our eyes on thoſe anatomical plates, in which

which are repreſented the ſkeletons of divers animals that have been diſſected. From man, the ape, and horſe, to the ſquirrel, weaſel, and mouſe, we ſhall ſee throughout the ſame deſign, the ſame arrangement, the ſame eſſential relations, except in a few particulars. The ſpine, which is formed of a ſeries of parts, joined to each other as by ſo many hinges, bears to its upper extremity a ſort of bony box, of greater or leſs extent. Some bony arches, which on one ſide are connected with the ſpine, and on the other with a part oppoſite to it, form another more ſpacious box. The upper and lower extremities are joined likewiſe to the ſpine by different interpoſed bands, and maintain the body in thoſe various attitudes its exigencies require. This œconomy is ſo generally obſerved, that it has even been remarked that the vertebræ of the neck are ſeven in number in all the ſpecies. Almoſt the ſame order is to be met with in birds and fiſhes. It varies more and more in reptiles, ſhell-fiſh, and inſects. The latter however have their bones, ſeveral parts of which ſeem to imitate the correſponding ones in great animals; but whereas among the latter the fleſh covers the bones; on the contrary, among inſects the bone covers the fleſh. In this numerous claſs of little animals, nature has in an eſpecial manner diverſified her models the moſt, and diſplayed the wonderful fecundity of her inventions. In the large parts of the animal kingdom ſhe pretty nearly purſues the ſame plan of architecture, and hardly diverſifies any thing but the orders. In one we behold the ſtrength and majeſty of the Tuſcan; in others the elegance and delicacy of the Corinthian. But when ſhe deſcends to inſects, ſhe ſeems entirely to change her plan, and to retain as little as poſſible of her firſt models. She ſeems at length to abandon them altogether in her formation of an arm or bell-polypus. She conſtructs plants on ſtill different models; but theſe models retain in them ſomething of the organization of animals, and particularly that of inſects. The organs of reſpiration are almoſt the ſame in the plant and inſect. Thoſe parts which are eſſential to life are diſperſed throughout the whole body of the plant, as they are in inſects, that are reproduced by

ſlips.

ſlips. Thoſe plants which appear to be moſt elevated in the ſcale, exhibit to us a ſtalk, branches, roots, leaves, flowers, and fruit. A ſwine-bread, an agaric, a liver-wort, on the contrary, are ſo extremely diſguiſed, and have in them ſo ſmall a reſemblance to plants, that it is neceſſary to have the eye of a ſtrict obſerver, in order to know and characterize them. Theſe half vegetable productions, if I may be allowed the phraſe, ſeem, in the vegetable kingdom to be what the gall-inſect, polypus, and the muſcles are in the animal. They do not appear to be more organized than an amianthus, a talc, or a cryſtal.

18. The diſtance however is much greater from the moſt regular foſſil, or that moſt reſembling a vegetable, to the plant in the leaſt degree ſo, or that is the leaſt organized. The foſſil does not grow, properly ſpeaking: it does not receve nouriſhment, nor engender. It is formed of the ſucceſſive appoſition of different molecules, which by uniting together under certain relations, determine its figure. The plant is a body truly organized, which of itſelf works the molecules, deſtined to incorporate themſelves with its ſubſtance, and to extend it every way, and contains little bodies reſembling it, which it nouriſhes, cauſes to expand themſelves, and by means of which it multiplies its being. Nature then ſeems to make a great chaſm in paſſing from the vegetable to the foſſil, &c. There are no bands, no links hitherto known to us, which unite the vegetable to the mineral kingdom. But ſhall we form our judgment of the chain of beings by our preſent degrees of knowledge? Becauſe we here and there diſcover in it ſome interruptions, ſome void ſpaces, ſhall we conclude from thence that they are real? Shall we imagine that a comet has ſplit the ſcale of our world, and deſtroyed the harmony of it? We are only beginning to ſurvey the vaſt cabinets of nature; and amongſt that innumerable multitude of various productions which ſhe has aſſembled, how many are there which we have not ſo much as ſeen, and can frame no idea of their exiſtence? Shall we haſten to decide concerning the reſult of theſe productions before

we

we have examined them all, or formed an exact liſt of them? The vacancy we ſuppoſe left between the vegetable and mineral, will in all probability be one day ſupplied. There was a ſimilar void betwixt the animal and vegetable: the polypus now fills it up and ſets in a conſpicuous light the admirable gradation there is among all beings. It is true we cannot form any main idea betwixt the plant and the foſſil; we do not imagine there is any ſhadowing between growth and apoſition: but had we formed any conception of the properties of the polypus? If thoſe marine productions, which have been called ſtony plants, were real plants, they were in ſome meaſure one of the links requiſite for uniting the vegetable to the mineral kingdom. But late diſcoveries have informed us, that theſe pretended plants are only works of certain polypuſes, that have the art of conſtructing caſes for themſelves. Thoſe coral flowers, ſo much celebrated, were real polypuſes, and this is another truth wherewith the polypus has enriched the phyſical world.

19. Organized bodies are tiſſues which are more or leſs fine pieces of net-work, or pieces of ſtuff, whoſe warp itſelf forms the woof, by an art which we ſhould think we could never enough admire, were we acquainted with it. Foſſils are a kind of inlaid work. We do not know where the organization ends, nor which is its ſmalleſt term. But by ceaſing to organize, nature does not ceaſe to diſpoſe or arrange. She even ſeems to organize when ſhe has made an end of doing ſo. One would be ready to imagine that fibrous and leaved ſtones were vegetables in part diſguiſed. The conſtant regularity of ſalts and cryſtals ſtrikes us in an equal degree. We may be aſſured, that the cryſtal is formed of the repetition of an infinite number of ſmall, regular and pyramidal bodies, properly laid on each other, which repreſent, in ſome meaſure, the whole exactly in miniature. We ſhould, notwithſtanding, be very much miſtaken, were we to conſider theſe little pyramids, as the germ of the cryſtal; it is ſtrictly ſpeaking no more than an element or conſtituent particle of it. It does not unfold itſelf, it remains

mains as it was; but it ſerves as a ſupport to other ſimilar pyramids which are to be joined to it, and thus to augment the cryſtaline maſs by ſucceſſive aggregates. The cryſtaline juice is not received, wrought, and aſſimilated by ſtrainers or veſſels that are more or leſs fine, or more or leſs folded together, within the pyramid; it is already entirely prepared when it procures the union of different molecules into one pyramidal maſs, by virtue of the laws of motion and attraction. This is the primary character which diſtinguiſhes brute from organized bodies: a character which we ought never to loſe ſight of, when we compare together beings of theſe two claſſes.

20 Thus the bodies of plants and animals are ſpecies of looms, machines more or leſs compounded, which convert into the proper ſubſtance of the plant or animal the various matters ſubjected to the action of their ſprings and liquors. Theſe machines, which are ſo ſuperior in ſtructure to thoſe of art, ſeem ſtill more ſo when compared in their eſſential effects. Thoſe matters which organical machines work, they likewiſe aſſimilate and incorporate with themſelves; they grow by this incorporation, augment in their dimenſions every way, and during their growth, all their parts preſerve among themſelves the ſame relations, the ſame proportions, the ſame exerciſe; all continue to diſcharge their proper functions: the machine remains in its extended ſtate, what it was in miniature. It is a ſyſtem, a wonderful aſſemblage of an almoſt infinite number of tubes, differently formed, calibered, and interwoven, that like ſo many filtres, purge, faſhion, and refine the nutritious matters. Each fibre, what I am ſaying? Each fibrillia is itſelf a machine in miniature, which by performing analogous preparations, appropriates to itſelf the alimentary juices, and gives them the arrangement ſuitable to its form and their functions. The whole machine is in ſome meaſure only the repetition of all theſe leſſer machines, whoſe united ſtrength conſpires to the ſame general end. The excellence of organical machines appears in a conſpicuous light from other ſtill more ſtriking inſtances.

They

They not only produce, from their own foundation, machines ſimilar to them, but a great number of them reproduce of themſelves, thoſe parts they had been deprived of, which various parts become afterwards as many machines, equally perfect with thoſe whereof they before only made a part.

21. To conclude: the ſame general deſign comprizes all parts of the terreſtrial creation. A globule of light, a molecule of earth, a grain of ſalt, a particle of mouldineſs, a polypus, a ſhell-fiſh, a bird, and a quadruped, man, are only different ſtrokes of this deſign; and repreſent all poſſible modifications of the matter of our globe. My expreſſion falls greatly beneath reality; theſe various productions are not different ſtrokes of the ſame deſigns; they are only ſo many various points of a ſingle ſtroke, that by its infinitely varied circumvolutions, traces out to the aſtoniſhed eyes of the cherubim, the forms, proportions, and concatenation of all earthly beings. This ſingle ſtroke delineates all worlds, the cherub himſelf is a point of it: and that adorable hand which drew this ſtroke, alone poſſeſſes the method of deſcribing it.

CONTENTS.

CONTENTS

OF THE

THIRD VOLUME.

CHAP. III.

Of Meteors.

		Page
	Of vapours, mists, and clouds -	3
2.	Of dew and rain - - -	5
	Mr. Kershaw's observation on dew -	6
	The various causes of rain - -	ib.
	A kind of bloody rain - -	7
	Other singularities in rain - -	8
3.	Of snow and hail - - -	ib.
4.	Of the rainbow - - -	10
5.	Of the halo, frequently seen round the sun or moon - - - -	11
6.	Of mock suns and moons - -	ib.
7.	Of thunder and lightning - -	12
8.	Of damps - - -	14
	Peculiar, fatal effects of damps -	15
	A kind of murrain ascribed to damps -	17

Page

9. Of Ignes Fatui: vulgarly called will with the wiſp - - - - - 18
Singular kinds of lambent fires - - 19
Water luminous in the gulf of Venice - 20
Various ſorts of fiſh that are luminous - 21
Of ſundry other luminous bodies - 22
Of the ſplendor of ſea-water - - 23
Of the light of a glow-worm - - 24
Of falling ſtars - - - - 25
10. Of electricity - - - ib.
New diſcoveries in electricity - - 28
Glaſs very difficultly electrified - - 32
Many appearances in nature accounted for by electricity - - - - 35
Common as well as electric fire is in all bodies - - - - 39
Experiment ſhewing that electric fire is the ſame as lightning - - ib.
Inſtance of a paralytic diſorder cured by lightning - - - - 40
Of the aurora borealis, or northern lights - 43
Of what is termed St. Helmo's fire - ib.
Electricity quickens all ſorts of motion - 44
Experiments on the electricity of hair - 45
Danger of dreſſing the head with metal pins or wire - - - - 47
11. Of ether of plants - - - 48
12. Of wind - - - - 49
The heat in the Weſt-India iſlands intolerable, were it not for the ſea-breezes - ib.
Extraordinary variation of winds at Aleppo, from extreme cold to extreme heat - 50
A wind of a peculiar kind paſſed over Rome in 1749 - - - ib.
Of the motions of hurricanes - 51
Of one ſpecies of hurricanes called water-ſpouts - - - 52
Diſtinct account of three water-ſpouts on the coaſt of Barbary - - - 53
Singularity of the ſtorms on the Fetter, a lake in Gothland - - - ib.
13. Reflections - - - 54

Of

Page

Of the uſefulneſs of the atmoſphere to the whole globe - - - 54
The excellent uſe of the atmoſphere in reſpect of two of its meteors, the winds, and the clouds and rain - - - 58
Farther reflections, in the words of Mr. Hervey - - - 60—67

PART THE FIFTH.

Of the Syſtem of the World: of the Heavenly Bodies; and of the Properties and Cauſes of Natural Bodies.

CHAP. I.

Of the Syſtem of the World.

1. The general phenomena of the ſun and moon 67
2. Of mercury and venus - - 68
3. Of the other planets: mars, jupiter, and ſaturn. - - - - ib.
4. Of the comets and fixed ſtars - - ib.
5. The Ptolemaic ſyſtem - - - 69
6. The Copernican ſyſtem - - ib.
7. The ſyſtem of Tycho Brache - - 70
8. The Hutchinſonian ſyſtem - - 71
9. The advantages of the rotation of the earth 75

CHAP. II.

Of the Heavenly Bodies in particular.

1. Of the ſun - - - - - 77
Mr. Huygens's obſervations on the ſun - 78
How the ſun is eclipſed - - ib.
2. Of mercury - - - - 79
3. Of venus - - - - - ib.
4. Of the earth - - - - - ib.
The different ſeaſons depend on the different poſitions of the earth with reſpect to the ſun - - - - ib.

Page

5. Of the moon - - - - 80
Of the motion of the moon - - 81
The opinions of various authors reſpecting the moon - - - - ib.
The moon ſuppoſed to be inhabited as well as the earth - - - - ib.
Mr. Huygens's obſervations on the moon - 82
The benefit we receive from the moon - 83
6. Of mars - - - - 85
7. Of jupiter, and his ſatellites - - ib.
8. Of ſaturn - - - - ib.
The magnitude of the different planets computed by miles - - - 86
9. Of comets - - - - ib.
Sir Iſaac Newton's obſervations on the extreme heat of comets - - - 87
Comets a peculiar kind of planets - ib.
The great uſe of comets - - ib.
Of the aſtronomy of comets - - 88
Of the power of attraction and repulſion in various bodies - - - 89
Of a ſpecies of comets that have no tails - 91
Comets with tails ſeldom viſible - ib.
10. The fixed ſtars - - - 93
Of the number of ſtars - - ib.
Of the ſeven ſtars - - - 94
Of the appearance and diſappearance of various new ſtars - - - ib.
11. Reflections - - - 95
On the ſituation of the heavenly bodies - ib.
On the motions of the heavens and the earth ib.
The diurnal motion of theſe globes - 96
The annual motions of the heavenly bodies ib.
The perpetuity, conſtancy, and regularity of thoſe motions - - - 97
Of the figures of the heavenly bodies - ib.
Of the peculiar advantages we receive from the ſun - - - - 99
Of the need of the abſence of the ſun in the night - - - 100

Farther

Page
Farther improvements, in the words of Mr. Hervey - - - - 102
Doubts concerning modern aſtronomy - 105
Mr. Kennedy's obſervations on aſtronomical chronology - - - - 111
Scriptural account of the poſition of the ſun and moon at the creation - - - ib.
Mr. Ferguſon's obſervations of the fixed ſtars 114
Mr. Boyle's remark upon the whole of Natural Philoſophy - - - ib.
Short obſervations on the whole preſent ſyſtem of Philoſophy - - - - 118

CHAP. III.

Of the Properties that are common to all Bodies.

1. Of extenſion - - - 133
2. Of a vacuum - - - ib.
3. Of ſolidity - - - - 134
4. Of diviſibility - - - ib.
5. Of motion and reſt - - - 135
6. Of the laws of motion - - ib.
7. Of the Ariſtotelic elements - - 136
8. Of the principles of the Chymiſts - ib.
9. Objections to them - - - ib.
10. What is the primary element of all things 137

CHAP. IV.

Of thoſe Things wherein Natural Bodies differ.

1. Of the particular properties of bodies - 138
2. Of light - - - - ib.
Particles of light attracted by thoſe of other bodies - - - - 139
Rays of light differ in various reſpects - 140
The effects of light and ſound - - 143
Remarkable account of the effects of muſic on animals - - - 144
The denſity of light - - - - 145

Page
Of elementary light - - - - 146
The inconceivable extenſion of light - 148
Of natural and artificial phoſphori: their ſurpriſing properties - - - - 149
3. Of colours - - - 151
Of ſecondary colours: with curious experiments thereon - - - 152
4. Of ſounds - - - 154
5. Of ſmells - - - - - - 155
Mr. Boyle's account of ſmells - - ib.
Fatal inſtance of the effluvia of flowers - 156
Effects of the effluvia of ſprings in England and abroad - - - - - ib.
6. Of taſtes - - - - - - 157
7. Of moiſture and dryneſs, heat and cold ib.
8. Of gravity - - - 158
Mr. Hutchinſon's account of gravitation 159
Mr. Hervey's ſtrong and beautiful obſervations on this head - - - - 160
Dr. Rogers's obſervation thereon - - 162
——— thoughts on comets - 164
9. Of the other properties of bodies - 166
10. Of occult qualities - - - 167
11. Reflections - - - - ib.
On the heavenly bodies - - - 168
On the earth - - - 169
On the natural inſtinct of animals - - 171
On ſeas and rivers - - - 174
On man in particular - - - ib.
On a general review of the whole - - 175

Abridgement of the CONTEMPLATION of NATURE.
By Mr. *Bonnet*, of *Geneva*.

Introduction - - - - 178

CHAP. I.

Of the Firſt Cauſe.

1. The firſt cauſe - - - 179
2. The Creation - - - ib.

Page

3. The univerſe conſidered with reſpect to its greater parts - - - - - - 180
With reſpect to the planetary ſyſtem - 181
4. With reſpect to comets - - - ib.
5. Of the ſuſpenſion of thoſe immenſe bodies in the air - - - - - - - 182
6. Of the ſea, iſlands, &c. - - 183
7. Of the moon, venus, mercury, ſaturn, and the ſun - - - - - - ib.
8. Univerſal connection, or harmony of the univerſe. - - - - - 184
9. The elements act reciprocally on each other 185

CHAP. II.

Of the relative Perfection of Beings.

1. General diſtribution of terreſtrial beings 186
2. Of corporeal perfection - - - 187
3. The terreſtrial life, and the ſpecies of it - ib.
4. The immenſity of the chain of beings - 188
5. Mean ſpaces: and their conſequence - ib.

CHAP. III.

General View of the gradual Progreſſion of Beings.

1. The elements - - - - 190
2. Three kinds of compoſition in bodies. - 191
3. Of fluids in general, and certain fluids in particular - - - - ib.
4. Of ſome rude or unorganized ſolids - 192
5. Paſſage of rude or unorganized ſolids into organized - - - - - 193
6. Of ſome ſpecies of plants, whoſe form differs greatly from that of thoſe moſt known to us - - - - 194
7. Of plants in general - - - - 195
8. A view of the exterior parts of plants - ib.
9. A view of the inſide of plants - - 197
10. Tranſition from vegetables to animals: the ſenſitive plant and the polypus - - 199

Page
11. Reflections on animal machines - - 201
12. Reflections on the polypus - - 202
13. Of worms that may be multiplied by ſlips 203
14. Of inſects in general - - - - ib.
15. The external parts of inſects - - 204
16. The inſide of inſects - - - 206
17. Paſſage from inſects to ſhell-fiſh: pipe-worms 207
18. Of ſhell-fiſh - - - - - ib.
19. Paſſage from ſhell-fiſh to reptiles, and of reptiles to fiſhes - - - - 209
20. Of fiſhes - - - - - ib.
21. Paſſage from fiſhes to birds: the flying-fiſh: water-birds: amphibious birds - 210
22. Paſſage from birds to quadrupeds: the bat: flying-ſquirrel: the oſtrich, &c. - 211

CHAP. IV.

Continuation of the gradual Progreſſion of Beings.

1. Of animals conſidered as mixed beings. Superiority which the faculty of feeling gives the animal over the plant - - 212
2. Difficulty concerning the conſtruction of the animal ſcale. Anſwer to this difficulty 213
3. Of the extent of inſtinct in animals: method of diſtinguiſhing it - - - 214
Inquiry concerning ſouls - - - ib.
4. Men endued with reaſon, cultivating the arts and ſciences - - - ib.
5. Man in ſociety - - - 216
6. Man in commerce with God by religion ib.
7. Gradations of mankind - - - 217
The celeſtial hierarchies - - - 218
Reflections - - - - - - ib.

CHAP. V.

Of the various Relations of Terreſtrial Beings.

1. The union of ſouls to organized bodies: the perceptions and ſenſations - - 221

Page

2. The paſſions: the temper - - 223
3. The memory and imagination - 224
4. The ſight - - - - - 225
5. Of colours: their conſequences - - 227
6. Of fire - - - - - 229
7. Of air - - - - - 231
8. The appropriation of animals to divers climates, places, and matters - 232
9. The union of terreſtrial beings by their mutual ſervices - - - - - 233
10. The transformation many things undergo, particularly by the action of organical machines - - - - - ib.

CHAP. VI.

Of Vegetable Oeconomy.

1. Of organical œconomy in general - 235
2. Nutrition of plants by the roots and leaves ib.
3. Direction of the leaves, their returning, the folding of the ſtalk - - 237
4. A ſketch of the theory of the motions of the ſap - - - - 238
5. Germination and growth - - 239
6. Multiplication by ſeed. Diſtinction of ſexes 240
7. Multiplication by ſhoots - - 241
8. Multiplication by ſlips, and grafting - 242
9. Regeneration of vegetables - - 244

CHAP. VII.

Of Animal Oeconomy.

1. The nerves: the ſpirits - - 246
2. The muſcles - - - 247
3. The organs of nutrition - - - ib.
4. The organs of circulation - - 248
5. The organs of reſpiration - - 249
6. Secretions - - - - ib.
7. Growth - - - - - - 250

Page
8. The germs - - - - - 251
9. The primitive ſtate of organized beings 254
10. Generation. The chick - - 255
11, 12, 13, Continuation of the ſame ſubject 256—258
14. The generation of mules - - - 259
15. The formation of monſters - - 261
16. Accidents may give birth to monſters - 262
17. Application to vegetables - - - 263
18. The myſtery of the generation of plants cleared up - - - - - - - - 264

CHAP. VIII.

Of Animal Oeconomy, conſidered in Inſects.

1. Introduction - - - - 264
2. The mechaniſm of reſpiration - - ib.
3. The circulation - - - - 265
4. The organs of generation, and their dependencies - - - - - 266
5. Diſtinction of inſects into viviparous and oviparous - - - - - - 267
6. Varieties of generation - - - 268
7. The vine-fretter - - - - 269
8. Zoophytes, or plant-animals without feet. Freſh-water worms - - - 271
9. Cluſter polypuſes - - - - 273
10. Funnel polypuſes - - - - 275
11. Net polypuſes - - - 276
12. The polypus with arms - - - 277
13. Philoſophical conſiderations on the ſubject of polypuſes - - - 278

END OF THE THIRD VOLUME.

special
collec.
BW264
.W4S8
1810
v. 3

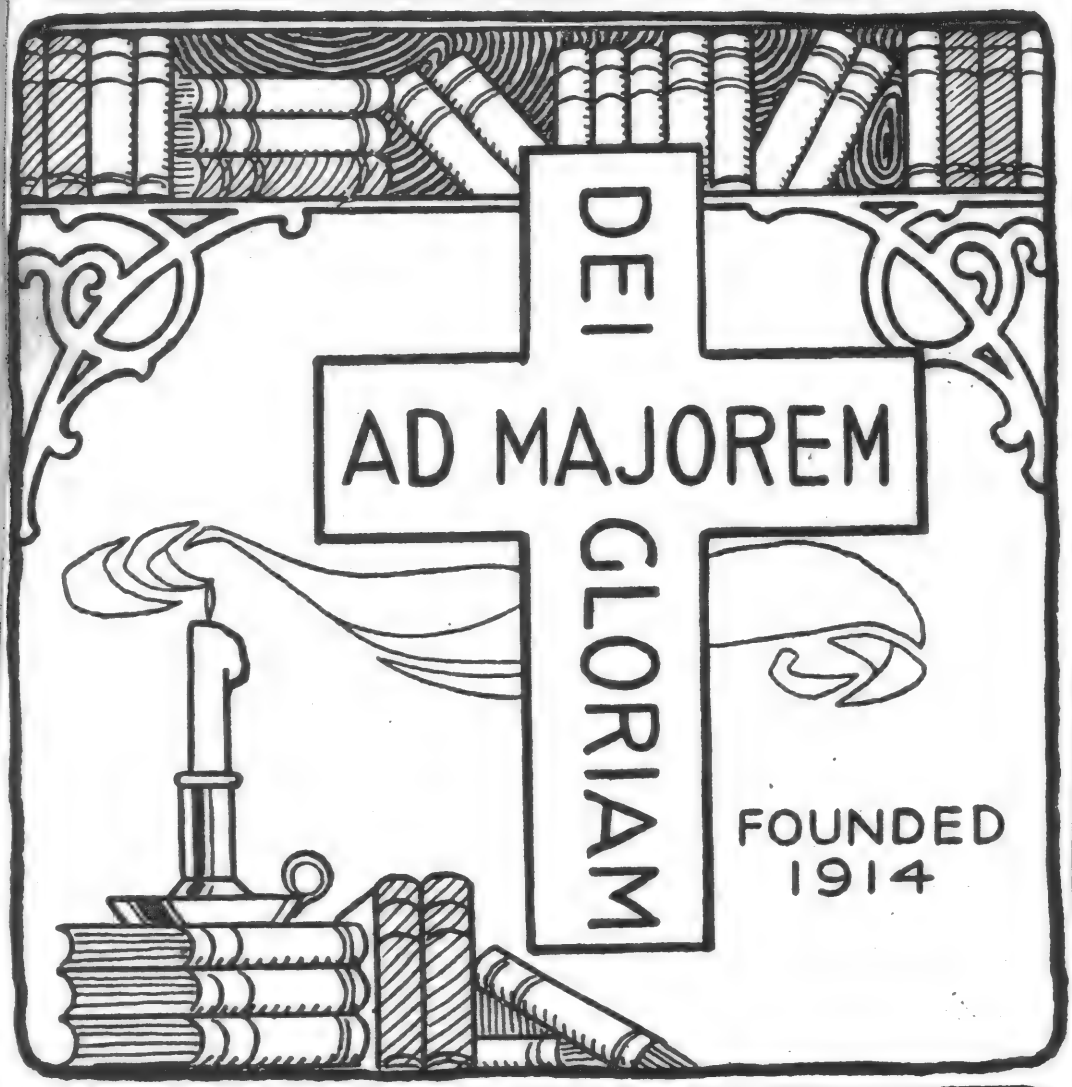

b

VOLUME 4

COLWELL,
OKBINDER.

BW 264
.W458 1810 v.4
1036

School of Theology



THEOLOGICAL LIBRARY
Thursfield Smith Collection, No._____

Wes 299

A

SURVEY

OF THE

WISDOM OF GOD

IN

THE CREATION:

OR, A

COMPENDIUM

OF

NATURAL PHILOSOPHY.

IN FOUR VOLUMES.

By JOHN WESLEY, M. A.

THE SIXTH EDITION.

VOL. IV.

These are thy glorious Works, Parent of Good,
Almighty! Thine this universal Frame,
Thus wond'rous fair! Thyself how wond'rous then!

MILTON.

DUBLIN:

PRINTED BY R NAPPER, 29, CAPEL-STREET

And sold at the Methodist Preaching Houses in Town & Country.

1810.

A

COMPENDIUM

OF

NATURAL PHILOSOPHY.

CHAP. IX.

Continuation of Animal Œconomy considered in Insects.

1. IN the ſeventh chapter you have ſeen the earth-worm regenerate; you have contemplated the progreſs of this regeneration; you have remarked a little bud that grew at the fore-part of the ſtump, which unfolding itſelf by degrees, became a vermiform appendage, a kind of little worm, that ſeemed to be ingrafted on the ſtump.

This animal bud has diſcovered to you the firſt origin of the part that is reproduced. You have perceived that it was lodged in a miniature under the fleſhy parts of the ſtump, and that the latter does not contribute more towards this production than the earth does to the plants that have taken root in it.

Thus the earth-worm contains, like the polypus, a multitude of germs, which begin to unfold themſelves as ſoon as certain accidents convey towards them the nutritious juices. The ſources of reparation are here in proportion to the accidents that may threaten the animal. But the reprobation of the earth-worm is much more aſtoniſhing than that of the polypus. It

is not only an enormous coloſſus in compariſon of the polypus, but its ſtructure is alſo much more compounded. It affords a more numerous apparatus of viſcera, veſſels, tracheæ, muſcles, &c. It has real blood, and this blood circulates. But it is beſides an hermaphrodite: it unites at once all the organs peculiar to the two ſexes. This inſect, which in appearance is the moſt contemptible, would alone be ſufficient to exhauſt the ſagacity of the ableſt obſerver, though applying himſelf ſolely to the contemplation of it. What a gainer would phyſiology be from ſuch inquiry? What a number of truths, concerning which we ſhould have no doubt, would then augment the treaſures of our phyſical knowledge?

2. The regeneration of freſh water worms preſents us with the ſame phenomena as that of the earth-worm, and their ſtructure is likewiſe very much compounded. Several ſpecies of them are principally diſtinguiſhed by their colour. All of them do not poſſeſs in the ſame degree the property of multiplying by ſlips. In general, the polypus greatly ſurpaſſes them them in this reſpect; perhaps, becauſe its ſtructure is more ſimple; and it may alſo be owing to its having a more ample proviſion of germs. Be that as it may, when we cut off the head or tail from the worms we are treating of, they do not themſelves become worms; but all, or the greateſt part of the intermediate pieces, how ſmall ſoever they be, very eaſily regenerate themſelves, and in a ſhort time produce an equal number of complete worms.

Regeneration begins by a little puffing up of the anterior extremity; this puffing ſeems analogous to the vegetable roll. The wound cloſes and quickly conſolidates. A little bud appears in the centre of the roll. This bud increaſes in ſize and length by degrees. New rings and new viſcera begin to appear. You ſee from the reſt what is to follow,

You alſo very eaſily comprehend after what manner each piece vegetates of itſelf. It has in miniature the ſame viſcera as the whole exhibited at large. You have not forgot that the parts eſſential to life are here

diſperſed

diſperſed throughout the whole body, and that circulation is performed in the ſmalleſt pieces as in the whole worm.

Little buds of tubercles ſometimes riſe on the bodies of theſe worms, and give room to think that they are young ones growing from them, ſlips reſembling thoſe of the polypus, having the ſame origin and end.

This ſpecies of worm, from certain pieces of which a tail ſhoots forth in the part where a head ſhould have been produced, affords a very ſingular phenomenon, which the frequency of it does not permit us to conſider as the mere effect of chance. It alſo proceeds leſs from chance than the production of this ſupernumerary tail. It is too well organized not to have the ſame origin as that which ſhoots forth at the poſterior extremity. But we cannot pretend to ſay what are the cauſes which here determine a tail to take the place of a head. We only know, that this kind of worm is very much expoſed to the loſs of its hind part: it is therefore in all probability furniſhed with more means for repairing this loſs, than that of the fore-part.

3. It would ſeem as if nature had propoſed to herſelf a kind of diverſion in the formation of inſects. She has laviſhly beſtowed on them members and organs, which ſhe has diſtributed but ſparingly to other animals; to one ſhe gives two hundred legs; to another twenty thouſand eyes; to a third ſeveral hundred lungs, &c. The production of new legs, new rings, a new head, and a new viſcera, ſeem in theſe inſtances to be attended with no greater labour or difficulty than the production of new hairs or new feathers.

She often likewiſe diſguiſes the ſame inſect, and preſents it to us ſucceſſively under ſuch oppoſite forms, that they ſeem to compoſe ſo many diſtinct beings. This leads us to the metamorphoſis of inſects.

4. We have had frequent occaſion to acknowledge, that the proceedings of nature are not always uniform, and that ſhe can accompliſh the ſame end by very different ways. Look at this little oblong, black, ſmooth,

and

and ſhining cone. It moſt reſembles thoſe cones which many inſects conſtruct to metamorphoſe themſelves in. However, it differs from them in ſome eſſential particulars. View it through a microſcope; you will then perceive in it ſome annular inciſions, but not very deep, which diſcover to you its true nature, and at the ſame time informs you, that it is nothing but the ſkin of a worm, which is become round, and has contracted a hardneſs. Open it gently with the point of a needle, you find nothing in it but a kind of pap, in which you are able to diſcover nothing. The inſect has but lately loſt its form of a worm; how has it been reduced into that ſoft ſubſtance? How will that become an inſect? Suſpend your queſtions, and open a cone that is leſs recent than this. What do you diſcover in it? A little maſs of oblong, whitiſh fleſh, in which you cannot perceive, even through a magnifying glaſs, the leaſt ſigns of members or organs. In a word, you have before you an oblong ball. Do not imagine that this ball is a caſe that contains a nymph: it is itſelf a nymph that is much diſguiſed. Preſs the ball a little: the legs begin now to ſhew themſelves: they come out of a little ſocket, that is at one of the extremities of the ball. Augment the preſſure by degrees; you will force all the parts of the nymph to appear. They therefore exiſt already: but they were ſunk and infolded within the ball, almoſt as the fingers of a glove might be in the hand of a glove.

If you could make the ſame experiment on the oviform bodies of net-polypuſes, and on the buds of arm-polypuſes, that you have lately made on the oblong ball, you would probably oblige the little polypus to produce itſelf, and by that means accelerate the time of its birth.

5. Inſects that paſs through the ſtate of an oblong ball can therefore form themſelves a cone of their own ſkin. All the parts of the nymph ſeparate themſelves by little and little from this ſkin. It grows round and hard about them; and under this ſingular arch they make an end of perfecting themſelves. They are at firſt only of the conſiſtence of a pap. This thickens

by

by degrees. It assumes the form of an oblong ball; and when all the members of the nymph have acquired a certain consistence, they issue one after another from the inside of the ball, and arrange themselves like those of other nymphs.

By becoming a kind of cone, the skin of the insect does not lose in all the species, the form that was proper to the worm; some of them preserve it so well, that the metamorphosed worm scarcely differs at all from the worm that has not been yet transformed.

6. A hen that should lay an egg as large as herself, from which a cock or a hen would be hatched, may offer to us such a prodigy, as we should find some difficulty in believing. A fly that is troublesome to horses, and whose form has caused it to be named the spider-fly, affords us such a prodigy; and it should not seem the less strange, because it takes place only in an insect. Were there a law in the organical kingdom, to which we knew no exception, it would assuredly be that which ordained every organized body to grow after its birth. Nevertheless, here is a fly that lays a species of egg, from which is produced another fly as large and as perfect as the mother. This egg is almost round, white at first, and afterwards of a black or ebony colour. The shell is firm and polished—but I must undeceive my reader: this is not a real egg, but has only the appearance of one; it is the insect itself that has assumed the form of an oblong ball in a cone made of its own skin. The thing is not the less wonderful on that account. All insects that metamorphose themselves go through their various transformations, out of the belly of their mother. They are indeed to grow considerably before they undergo their first transformation, but do not grow at all afterwards. We have then an insect that transforms itself in the very belly of its mother, and acquires no farther growth after it has issued from it.

These cones of the spider-fly, these pretended eggs have been opened at different times; and in them have been found the same things that are discerned in the oblong ball-nymphs, when observed at their different

ages.

ages. Moreover, there have been diſcerned ſtigmata in this ſpecies of cone that might be taken for a real egg, which is an evident proof that it was the ſkin of a worm that has transformed itſelf under this very ſkin. An egg is without motion: our cone has ſome that are very viſible, and in certain circumſtances the inſide admits of their being ſeen, which attracts the attention of the obſerver. He ſeems to diſcern little clouds that ſucceed each other without interruption, and that paſs with a progreſſive and uniform motion, from one end of the cone to the oppoſite one. In the cones that are laid before the time, theſe ſhadowy layers have a contrary direction from that which they have in the cones at the full time. You have ſeen that the circulation varies its courſe in the nymph; ſince our ſhadowy layers change their's likewiſe, they pretty clearly indicate to us, that the abortive cone is the worm itſelf, that has not yet gone through its metamorphoſis. This worm is in truth a very ſingular being; it has neither head, mouth, nor any member: it is in appearance nouriſhed like the eggs of birds, in the trunks that encloſe them. A nice diſſection demonſtrates the ovary of the fly, and the worm lodged in the middle.

7. When animals were divided into viviparous and oviparous, it was thought that all the ſpecies were comprehended. The vine fretter came firſt to claſh with this famous diviſion, and convinced us that an animal was at the ſame time viviparous and oviparous. The arm-polypus next appeared, and preſented us with an animal, that multiplying by ſlips, might with good reaſon be called ramiparous. There have even been obſervations made which ſeem to prove that it is likewiſe oviparous. Another ſpecies of polypus, that multiplies alſo by ſlips, and is extremely well characteriſed by a ſort of plume, lays real eggs. Theſe eggs may be preſerved in a dry place for the ſpace of whole months, like the ſeed of ſilk-worms; and if afterwards ſown in water, there will be produced from them as many polypuſes. The bulb-polypus may be depicted by the epithet of bulbiparous.

But

But how ſhall we deſcribe the multiplication of other cluſter-polypuſes, that of the net-polypuſes, and of millipes? Laſtly, the ſpider-fly preſents us with another method of multiplying, in which there is nothing that is common with any of thoſe above-mentioned, and which is attempted to be expreſſed by the term of nymphiparous. How many other methods of propagating will there be diſcovered every day for which it will be neceſſary to create new terms!

8. One animal does not differ more from another than a worm from a nymph. And what renders this metamorphoſis ſtill more ſurpriſing is, that it ſeems to be performed inſtantaneouſly.

What then is the procedure of nature in this reſpect? She in other inſtances advances by degrees. An inſenſible developement brings all organized bodies to a ſtate of perfection. Can this law, which is ſo univerſal, ſuffer any exception? A fact which I am going to relate will help us to penetrate this myſtery.

Let us confine ourſelves to caterpillars; they are ſufficiently known to us, ſince the ſilk-worm is a real caterpillar. The caterpillar from time to time changes his ſkin, and that is common to him and moſt other inſects. Theſe moultings are termed maladies in the ſilk-worm, and they are ſo in effect. But it is very material to obſerve, that the ſkin which the caterpillar caſts off at each moulting is ſo complete, that it ſeems to be of itſelf a real caterpillar. There is found in it a head, eyes, a mouth, jaws, legs, armed with hooks, ſtigmata, and generally all the external parts proper to the inſect.

How is the caterpillar enabled to diveſt itſelf of ſo many organs, and clothe itſelf with new ones reſembling the firſt? Nothing can be more ſimple than this: new organs were lodged in the old ones, as in ſo many caſes or ſheaths. In changing its ſkin, the caterpillar had occaſion only to draw them away, and drew them accordingly, becauſe the caſes proved too ſtrait.

This jointing is ſo real, that it may be perceived by the naked eye. It may even be demonſtrated by a very eaſy experiment. If on the approach of the

moulting, we cut off the former legs of the caterpillar, ſhe will iſſue from her ſpoils without any legs at all. Thus this caterpillar, which we conſidered as a ſimple and ſingular being, was in ſome meaſure, a multiplied being, or compoſed of ſeveral ſimilar beings jointed into each other, and that ſucceſſively unfold themſelves.

9. Hence ariſes a very probable conjecture: may not the chryſalis be lodged under the laſt ſkin the caterpillar is to caſt off? May not this ſkin be a maſk that conceals it from our ſight?

A celebrated obſerver has, by a deciſive experiment, aſſured himſelf of the truth of this conjecture. He has removed the maſk, and has by this means diſcovered the chryſalis in a manner very eaſy to be diſtinguiſhed. He has ſeen the ſix legs of this chryſalis to grow out of the ſix former legs of the caterpillar, and all the other members of the latter to be wrapped together under different parts of the former.

The metamorphoſes of inſects, then, enter anew into the order of developements, and confirm it. The chryſalis, or rather the butterfly, for it is in the ſtricteſt ſenſe but a ſwaddled butterfly; the chryſalis, I ſay, pre-exiſted in the caterpillar. It does no more than unfold itſelf in it, and the caterpillar is a kind of machine prepared for performing afar off this developement. It is in ſome reſpects, to the chryſalis, what the egg is to the chick.

10. In truth an inſect that muſt moult five times before it is inveſted with the form of a chryſalis, is a compound of five organized bodies, encloſed within each other, and nouriſhed by common viſcera, placed in the centre.

As the bud of a tree is to the inviſible buds its encloſes, ſo is the exterior part of the caterpillar newly hatched to the interior bodies it conceals in its boſom. Four of theſe bodies have the ſame eſſential ſtructure, and this ſtructure is that which is peculiar to the inſect in the ſtate of a caterpillar. The fifth body, which is very different, is that of the chryſalis. The reſpective

tive ſtate of theſe bodies are in proportion to their diſtance from the centre of the animal. Thoſe that are the fartheſt off have more conſiſtence, or unfold themſelves ſooneſt.

When the exterior body has attained its full growth, the interior, which immediately follows, is conſiderably unfolded. It ſoon finds itſelf lodged in too narrow a compaſs. It ſtretches on all ſides the ſheaths that encompaſs it. The veſſels which convey the nouriſhment to theſe coverings being broken or ſtifled by this violent diſtention, ceaſe to act. The ſkin wrinkles and dries up. At length it opens, and the inſect appears clothed with a new ſkin and new organs.

A faſt of a day or two precedes each moulting. It is probably occaſioned by the violent ſtate in which all the organs then are. Perhaps it might be alſo neceſſary in order to promote the ſucceſs of the operation, and prevent obſtructions. Be this as it may, the inſect is weak after every moulting. All its organs are yet affected by the ſtate they were in under the covering they are juſt diſengaged from. The ſcaly parts, as the head and legs are almoſt entirely membraneous, and are all imbued with a liquor that inſinuates itſelf betwixt the two ſkins, and facilitates their ſeparation. But this moiſture evaporates by degrees: all the parts acquire a conſiſtence, and the inſect is in a condition to act. The firſt uſe that ſome ſpecies of caterpillars, which live only on leaves, make of their new teeth, is to devour greedily their ſpoils: ſometimes they will not even wait for doing it, till their jaws have received their full degree of ſtrength. Can theſe ſpoils be a proper aliment to renew and increaſe their ſtrength? Some caterpillars have likewiſe been ſeen to gnaw the ſhells of their eggs after they have iſſued from them, and even that of the eggs of ſuch caterpillars as have not been hatched.

11. When we have once conceived that all the exterior parts of the ſame kind are jointed into each other, or laid one on another, the production of new organs has nothing embarraſſing in it; and with regard to this, there is not any eſſential difference betwixt

twixt the five moultings that precede the transformation. Nothing more is requiſite in all that, but a ſimple developement.

But it is not abſolutely the ſame with reſpect to changes that happen in the viſcera before, during and after the metamorphoſis. Here the light that ſhould guide us is almoſt extinguiſhed, and we are conſtrained to grope in the dark.

It does not appear that the inſect changes its viſcera as it does its ſkin. Thoſe which exiſted in the caterpillar, exiſt likewiſe in the chryſalis; but they are modified, and it is the nature of theſe modifications, and the manner by which they are performed, which elude our reſearches.

A little before the metamorphoſis, the caterpillar rejects the membrane that lines the inſide of the inteſtinal bag. This bowel which has hitherto digeſted groſs food, muſt hereafter digeſt that which is extremely delicate. The blood that circulates in the caterpillar, from the hind part towards the head, circulates a contrary way after transformation. If this inverſion be as real as obſervations indicate, what idea does it not give us of the changes the inſide of the animal experiences? Thoſe which the circulation of the blood in a new-born infant undergoes, are in a manner nothing in compariſon of them.

12. Whilſt nature is labouring to change the viſcera, and to give them a new life, ſhe is employed at the ſame time in the developement of divers organs, which were uſeleſs to the inſect while it lived under the form of a caterpillar, and which the new ſtate whereunto it is called renders neceſſary for it. The better to enſure the ſucceſs of her different operations, ſhe cauſes the inſect to fall into a deep ſleep, during which ſhe carries on her work at leiſure and by inſenſible degrees.

The little wounds which the rupture of ſeveral veſſels has occaſioned in divers parts of the inſide, conſolidate inſenſibly. Thoſe parts which had been put into a violent exerciſe, or whoſe forms and proportions had been modified to a certain degree, conform themſelves

ſelves gradually to theſe changes. The liquors which are obliged to paſs through new channels, take that direction by little and little. Laſtly, the veſſels which were proper to the caterpillar, ſome of which occupied a conſiderable place within it, are effaced or converted into a liquid ſediment, which the butterfly rejects after having laid aſide the ſheath of the chryſalis.

13. When we conſider the metamorphoſes of inſects, we are ſurpriſed at the ſingularity of the means which the Author of nature has thought proper to make choice of, in order to bring the different ſpecies of animals to perfection.

Wherefore is the butterfly not bred a butterfly? Why does it paſs through the ſtate of a caterpillar, and that of a chryſalis? Why do not all the inſects that metamorphoſe themſelves undergo the ſame changes? Whence does it happen, that amongſt the ſpecies that aſſume the form of a nymph, ſome ſhed the ſkin of a worm, whilſt others retain it? How does it alſo come to paſs that among ſuch inſects as paſs through the ſtate of the worm-ſkin nymph, ſome take that form in the very belly of their mother?

Theſe queſtions, like all thoſe which may be ſtarted concerning eſſences, derive their ſolution from the general ſyſtem which is unknown to us.

Without endeavouring then to penetrate into the cauſe of the metamorphoſes, let us obſerve attentively the fact, and its immediate conſequences.

Let us conſider the variety which thoſe metamorphoſes diſperſe throughout nature. A ſingle indivdual unites within itſelf two or three differeut ſpecies. The ſame inſect ſucceſſively inhabits two or three worlds: and how great is the diverſity of its operations in theſe various abodes!

Let us alſo remark to what degree the relations which the fly or butterfly maintains with the beings that ſurround them, are multiplied by their metamorphoſes. Let us fix our attention on the cone of the ſilk-worm; and admire what a number of hands and machines this little ball ſets to work. What prodigious riches ſhould we have been deprived of, had

the

the butterfly of the ſilk-worm been originally produced in that form!

Inſects that undergo transformations, have not yet afforded us any ſpecies that multiplies by ſlips and ſhoots. This will not ſurpriſe us, when we reflect on the great compoſition of the bodies of theſe inſects. But let us not be too haſty in our judgment, nor conclude that the property of multiplying by ſlips and ſhoots is incompatible with metamorphoſes. Nature is too little known to us, to give us a right to form ſuch concluſions. Vine-fretters and polypuſes have furniſhed us with good preſervatives againſt too general concluſions.

CHAP. X.

Parallel between Plants and Animals.

1. IN our reſearches into the gradual progreſſion of beings and organical œconomy, we had frequent occaſion to compare vegetables and animals with each other. Let us here collect in one view thoſe various marks of analogy which are ſcattered hither and thither: let us repreſent them as in a picture, wherein by a nearer deſcription of them, they will agreeably attract our attention. We will afterwards inquire if there be any character which eſſentially diſtinguiſhes the vegetable from the animal.

2. A ſeed is an organized body, which under various coverings, thicker or thinner, and more or leſs numerous, contains within it a plant in miniature. A whitiſh ſubſtance, of a ſpongy nature, fills the capacity of the ſeed. Small veſſels which proceed from the germ, are in every part of this ſubſtance, dividing and ſubdividing

ſubdividing it. After being laid in the earth, moiſtened and warmed to a certain degree, the ſeed begins to ſhoot up. The moiſture, which has penetrated its outward folds, diſſolves the ſpungy ſubſtance, and mixes with it. Of this mixture is formed a kind of milk, which being carried to the embryo by the little veſſels, furniſhes it with a nouriſhment adapted to its extreme delicacy. The radicle or little root begins by this means to unfold itſelf. It increaſes in bulk and extent every day. In a ſhort time it becomes ſenſible of too cloſe a confinement: it makes an effort to come forth. A ſmall orifice, made in the exterior ſurface of the ſeed, facilitates its egreſs. The root inſenſibly ſinks into the earth, and derives from thence more ſubſtantial and copious nouriſhment. The ſmall ſtalk, which till this time lay hid under the coverings of the ſeed, now begins to ſhew itſelf. The teguments unfold themſelves in order to admit a free paſſage for it. Strengthened by an acceſſion of freſh juices, it pierces through the earth, and advances into the air.

3. An egg is an organized body, which under divers teguments, of various ſtrength and number, encloſes an animal in miniature. A fluid matter of a glutinous nature, fills the inſide of the egg. A number of infinitely ſmall veſſels ſpread themſelves out in this matter, and are connected with the germ by different branches. Being warmed in a ſufficient degree, either by nature, or art, the inſide of the egg begins to receive life. By means of a gentle heat, the matter ſurrounding the germ inſinuates itſelf into the ſmall ramifications, from whence it paſſes into the heart, whoſe motion it augments. Thus the animal becomes a living creature. It encreaſes in ſize and ſtrength every day, by receiving freſh ſupplies of more nouriſhing and perfect juices. After theſe juices are exhauſted, the animal has acquired all the growth it was capable of in the egg. It finds the apartment aſſigned it to be too narrow. It endeavours to ſet itſelf at liberty. Nature has provided it with an eaſy method of affecting this, either by arming it with inſtruments proper for piercing or tearing the coverings

which

which encloſe it, or by giving to the egg ſuch a ſtructure as favours its efforts. The animal is produced, and enjoys a new life.

4. The ſeed then is to the plant what the egg is to the animal. But the plant is not only oviparous but likewiſe viviparous; and the fœtus is the ſame with reſpect to the animal, as the bud is to the vegetable.

Being concealed under the rind, the bud there receives its firſt growth. It is minutely encloſed in membraneous teguments, analogous to thoſe of the ſeed. It adheres to the bark by ſmall fibres, which tranſmit a nouriſhment to it, adapted to its ſtate. When it has arrived to a certain bulk, it penetrates the rind in order to come forth. At its firſt appearance, it bears the infolding coverings along with it, from which it is ſoon releaſed. However, being as yet too feeble to ſubſiſt without the aliment provided by the mother, it continues to cleave to her; and cannot for a long time be ſeparated, without endangering it.

Being lodged in the matrix, the fœtus there receives its firſt growth. It is there contained at firſt in miniature, in the membraneous encloſures reſembling thoſe of the egg. It ſhoots forth ſmall veſſels in the matrix, which convey thither the nouriſhment neceſſary to promote its growth. When it has arrived to a certain ſize, it burſts theſe encloſures, and comes into the world. Sometimes theſe encloſures accompany it at its iſſuing forth. After it is produced, the little animal is not always able to provide for itſelf without the aſſiſtance of the dam. She muſt ſtill furniſh it with ſuſtenance, which it cannot diſpenſe with the want of, for a certain time without danger.

5. The plant is nouriſhed by the incorporation of ſubſtances received from without: theſe matters are very heterogeneous. Being pumped by the pores of the roots, or by thoſe of the leaves, they are conveyed into the utriculi, where they ferment and digeſt. They paſs into the ligneous fibres, which tranſmit them to the proper vaſes, where they appear under the form of a juice,

a juice, which is more or leſs coloured. The ramifications of the proper vaſes afterwards diſtribute them into all the parts, to which they are united by new filtrations.

Tubes made of a ſilvered blade, which are elaſtic, and turned ſpirally like a ſpring, accompany the veſſels which contain the ſap in their courſe. Being appointed for the purpoſe of reſpiration, theſe tubes introduce a freſh elaſtic air into the plant, which prepares and ſubtilizes the ſap, and probably colours it, beſides contributing to its motion: the ſuperfluous matter, or that part which is not ſo proper to be mixed with the plant, is conveyed to the ſurface of the leaves, whence it evaporates by an inſenſible but very copious tranſpiration. Globules, veſicles, or other excretory organs, which are diſtributed among the young ſhoots or leaves, procure an evacuation of the groſſer matter, and ſuch as is of a ſtronger conſiſtence.

The animal is nouriſhed by the incorporation of matter which proceeds from without. This matter is very heterogeneous. Being received by the mouth, it is conveyed into the ſtomach and inteſtines, where it undergoes different preparations: it paſſes into the lacteal veins, and their dependencies, or in other like veſſels, whereby it is tranſmitted into the blood-veſſels, where it appears under the form of a fluid more or leſs coloured, or flowing. The ramifications of the blood-veſſels afterwards diſperſe it into all parts, with which it incorporates itſelf by new preparations.

Pipes compoſed of cartilaginous rings, or of a ſilvered and elaſtic blade, turned ſpiral-wiſe, communicate with the blood-veſſels, or follow them in their courſe. As they are appropriated to reſpiration, they introduce into the animal a freſh and elaſtic air, which prepares, attenuates, and probably colours the blood, contributing likewiſe to its motion. The ſuperfluous matter, or ſuch part of it as is improper to be united with the animal, is carried to the ſurface of the ſkin, from whence it evaporates by an inſenſible, but very copious tranſpiration. Glands, or other emunctory organs, placed in different parts of the body, procure the evacuation of the groſſer matter.

6. The

6. The plant grows by unfolding, or the gradual extenſion of its parts in length and width. This extenſion is followed by a certain degree of hardneſs contracted by the fibres. It diminiſhes as the hardneſs increaſes. It entirely ceaſes when the fibres are ſo far hardened as not to yield to the force which tends to enlarge their ſurface.

The plants which become hardened the lateſt, are thoſe which are the longeſt time in growing. Herbs grow and harden faſter than trees. Some of them ceaſe to grow at the end of a few weeks, or even a few days. Among the laſt, ſome continue to grow for a great number of years, and even for ages.

We obſerve analogous difference between individuals of the ſame ſpecies. Some harden ſooner, grow in a leſs degree, or continue ſmaller; others harden later, and become larger.

The bud has nothing ligneous or woody in it.—Being herbaceous in every part of its ſubſtance, it becomes ligneous by degrees. Its ſtalk is formed of a prodigious number of concentric blades one in another, which are diſpoſed according to its length, and compoſe different bundles of fibres, which are themſelves formed of a prodigious number of leſſer fibres.

At the centre of the ſtalk is placed the pith; and the ſpaces which are left between the blades, are likewiſe filled with a pithy ſubſtance.

From the thickneſs of the blades reſults its growth in width; from the lengthening of the blades its growth in length proceeds. All the blades grow and harden one after another. Every blade grows and hardens alike ſucceſſively throughout its whole length. That part of every blade which grows and hardens firſt of all, is that which compoſes the baſe of the ſtalk. The blade which grows and hardens firſt, is the innermoſt, or that which immediately encompaſſes the pith. This blade is again covered with another, which being more ductile extends itſelf the more. A third blade encloſes this laſt, which as it hardens ſtill later, is a longer time in its growth. The caſe is the ſame with regard to a fourth, fifth, or ſixth. All theſe thus diminiſhing in thickneſs, and inclining towards the axis

of

of the ſtalk as they approach its upper extremity, form ſo many little cones ingrafted into each other, from whence proceeds the conic figure of the ſtalk and branches.

From the aſſemblage of little cones which become hardened during the firſt year, is formed a cone of a woody nature, which determines the growth of that year. This cone is encloſed in another herbaceous cone, which is only the rind, and which the following year will produce a ſecond ligneous cone, &c. When the wood is once formed, it does not extend itſelf any farther. So that in cicatrices, grafts, and different kinds of tumours, the rind is the only part that is employed. By ſtretching, thickening, or ſwelling itſelf, the rind inſenſibly forms a roll, and produces excreſcences which are more or leſs conſiderable, in proportion to the eaſe with which it is diſtended, or according to the quantity of juices it receives.

7. The animal grows by expanſion, or by the gradual extenſion of its parts in every ſenſe. To this extenſion there ſucceeds a hardneſs in the fibres. The extenſion diminiſhes as the hardneſs increaſes. It ceaſes when the hardneſs has arrived to ſuch a pitch, as not to admit of the fibres giving way to the force which contributes to enlarge their coats.

Thoſe animals, in which this hardneſs is formed lateſt, are longeſt in their growth. Inſects grow and harden in a much leſs time than great animals. Some of them ceaſe growing at the end of ſome weeks, and ſometimes in a few days. Of the latter ſome continue growing for a great number of years, and even ſome ages.

One may obſerve analogous differences in the growth of individuals of the ſame ſpecies: ſome of which that harden later than others, acquire a greater bulk.

The fœtus, in its original ſtate, contains nothing of a bony nature. As it is membraneous throughout; it only becomes bony by degrees. The bones are compoſed of a prodigious number of blades, folded in each other: lying, according to the length of the bone, and forming

forming various collections of fibres, which are themſelves compoſed of the re-union of a great number of little fibres.

In the centre of the bone is placed the marrow. The ſpaces left between the blades are filled with a medullary ſubſtance.

From the thickening of the blades the growth of the bone proceeds. From the lengthening of them, their extending in length. All theſe blades grow and harden after one another. Each blade grows and becomes hard in a like ſucceſſive manner throughout its whole length. That part of the blade which grows and hardens firſt, compoſes the body of the bone, which immediately encloſes the marrow. This blade is again covered with a ſecond, which being more ductile ſtretches itſelf in a greater degree. A third blade again infolds this, which as it hardens later than the others, is a longer time in its growth. It is the ſame with reſpect to a fourth, fifth, or ſixth. As they all thus diminiſh in thickneſs, and detach themſelves from the axis of the bone, the nearer they approach to its extremities, they form ſo many little columns, infolded within each other, which increaſe in diameter at their extremities. From hence we deduce the figure peculiar to long bones.

The growth of the bone during the firſt year, is attributed to the number of blades which become hardened in that year. This bone is covered over again with a great number of membraneous blades, that bear the name of periofteum, which as they gradually extend and harden, conduce to the increaſe of the bone in every part of it. The bone when it is once formed, extends itſelf no farther.

Thus in fractures, anchyloſes, and the different ſpecies of excreſcences, whether natural or accidental, the periofteum is the only part of the bone that labours. By ſtretching, thickening, and ſwelling itſelf, the periofteum reſtores the bone inſenſibly, produces a calloſity, and forms greater or leſs tumours, in proportion to the facility wherewith it extends itſelf, or as it is more or leſs ſupplied with juices, or with ſuch as are more or leſs viſcous.

8. The

8. The duſt or fine powder of the ſtamina, is the principle which fertilizes the ſeed. The piſtil is the place where this fecundation is performed.

Being contained in certain veſicles, the fecundating duſt is diſcovered in them by a microſcope, under the appearance of a groupe of minute, regular bodies, for the moſt part of a ſpherical or elliptic form, which being moiſtened, open themſelves, and emit a thin vapour, in which there floats a great number of exceeding ſmall ſeeds, which ſeem to move on all ſides. The duſt itſelf, when put into a drop of water, moves ſeveral ways with great rapidity.

The piſtil is compoſed of three principal parts; the baſe, the cups, and the top. The baſe contains one or more cavities, where the grain is lodged. The cups are long tunnels, whoſe baſe or aperture is turned towards the top. This is generally furniſhed with ſeveral nipples, each of which is perforated, having their diameter correſponding with that of a ſmall grain of the duſt.

Being in the lower part of the cup, the minute grains are preſſed in them more and more by the ſtraitneſs of theſe pipes. They are therein moiſtened with a juice that lines their ſides. They open themſelves and eject the ſeminal vapour, which penetrates to the ſeed, and promotes fecundation.

Several ſpecies of plants have two ſorts of individuals, viz. 1. Such individuals as only bear ſtamina, and theſe are males; and two individuals that have only the piſtil, which are females.

In a great number of ſpecies, every individual is an hermaphrodite, which unites both ſexes, the ſtamina and the piſtil. Sometimes this union happens in the ſame flower; then the ſtamina ſurround the piſtil. At other times it is only effected on the ſame branch; ſo that the ſtamina are placed on one part, and the piſtil on another.

9. The ſeminal liquor is the principle of fecundation in the egg. The matrix or ovaries are the places where it is performed.

Being

Being enloſed in the ſeminal veſſels, the fecundating liquor appears in them, through a microſcope, like a maſs of ſmall regular bodies, of different lengths, which ſeem to ſeparate themſelves into a great number of extremely minute grains, moving different ways. Sometimes theſe corpuſcles reſemble caſes with ſprings, which when moiſtened, open themſelves, and dart forth a limpid matter abounding with a great number of very ſmall grains.

The matrix conſiſts of three principal parts, or dependencies; the fundus or bottom, the fallopian tubes and the ovaries. The fundus contains one or more cavities, in which the embryos receive nouriſhment and expand themſelves: it has an orifice in the forepart. The fallopian tubes are a kind of long funnels, whoſe aperture is directed towards the ovaries, where it ends. The ovaries are a maſs of veſicles that are real eggs.

When the moſt ſubtle part of the ſeminal liquor has arrived through the fallopian tubes to the ovaries, it there fecundates one or more eggs. Theſe afterwards deſcend by theſe tubes into the matrix, where they are fixed and unfold themſelves. In oviparous females the eggs are contained in a kind of bowel, wherein they receive their growth: the ſeminal liquor makes them fruitful.

Moſt animals conſiſt of two ſorts of individuals; male and female. But there are other ſpecies, of which every individual is an hermaphrodite, which unites the two, although it cannot fecundate itſelf. In ſome ſpecies, where a diſtinction of ſexes is obſerved, there is no coupling, properly ſo called; the male only communicates his liquor to the eggs which the female has depoſited. Finally, ſome ſpecies are propagated without any apparent or external fecundation.

10. A plant does not only multiply by ſeeds, and buds; it is likewiſe propagated by ſuckers and ſprigs. It may alſo be multiplied by ſlips and ingraftings.

A tree ſends forth ſmall buds from various parts of its ſurface. Theſe buds increaſe in bulk; they open and diſcloſe the ſhoot, which extends itſelf every day.

While

While it is expanding itſelf, other ſtill ſmaller ſprigs ſhoot from it. Theſe in their turn are ſucceeded by leſſer ones; all of which are ſo many trees in miniature; and the nouriſhent received by one of theſe ſprigs is communicated to the whole plant.

When it has attained to a certain ſize, and is ſeparated from the trunk either by nature or otherwiſe, theſe ſhoots ſuſtain themſelves, and become ſo many diſtinct trees. Being cut into pieces according to their width, or even their length, theſe ſhoots will grow again of themſelves, and will become as many trees as they were made ſlips of. The leaves themſelves when ſeparated from their ſhoots, may afford ſo many complete plants. Being faſtened cloſely to each other, or inſerted in one another, ſeveral of theſe ſhoots, whether taken from the ſame or from different individuals, will unite together in ſo intimate a manner, that they will receive reciprocal nouriſhment, and form one individual whole.

The animal is not only propagated by eggs and living young, but likewiſe by ſhoots. It may alſo be multiplied by ſlips and ingraftings. A polypus ſends forth little buds from different parts of his body.—Theſe buds grow big and lengthen inſenſibly. Every one of them is a young ſhoot. While it is unfolding itſelf, there ſprings from it other ſmaller ſhoots. Theſe in their turn produce ſmaller ſtill. All theſe ſhoots are ſo many little polypuſes, and the nouriſhment one of theſe polypuſes receives, is communicated to their whole number. When they have arrived to a certain ſize, they ſeparate themſelves from the trunk, and become ſo many individuals.

Being cut into little bits, either tranſverſely or length-wiſe, the polypuſes grow up again from the ruins, and become as many complete ones as they were pieces. They very ſkin, or even the leaſt fragment of them, is capable of affording one or ſeveral polypuſes.

11. The generation of vegetables is not conſtantly regular. The laws by which they operate are ſometimes infringed. From them ariſe various ſpecies of monſters.

monſters. Sometimes they are compounded leaves, whoſe ſmaller ones are more or leſs numerous, or more irregularly ſhaped, or diſtributed with leſs ſymmetry than uſual. Sometimes there are flowers which have neither ſtamina nor piſtils, and whoſe petals being greatly multiplied, ſeem to have abſorbed theſe eſſential parts. Sometimes two fruits cleave together by a natural graft, or are encloſed in each other. Sometimes there are flowers or fruits whoſe form differs widely from that which is peculiar to the ſpecies.—Laſtly, There are productions which do not properly belong to any particular ſpecies, becauſe they derive their original from ſeeds that have been fecundated by duſt of a different ſpecies.

The generation of animals is not conſtantly regular: the laws by which it is governed are ſometimes diſturbed; whence are produced the different ſpecies of monſters. Sometimes there are hands and feet, whoſe fingers or toes are fewer or more in number, or formed in an irregular manner, or otherwiſe diſpoſed than uſual. Sometimes there are fœtuſes, in which the parts of generation are obliterated. Sometimes there are two eggs or two fœtuſes that cleave to each other by a natural coheſion, or that are contained in one another. Sometimes there are eggs or fœtuſes whoſe form is greately different from that which is peculiar to the ſpecies. Laſtly, there are productions that partake of two ſpecies, becauſe they are produced from ſuch females as are fecundated by males of different ſpecies.

12. The laws reſpecting the nutrition and growth of vegetables are liable to greater diſorders, than thoſe of generation. From hence are derived the different kinds of maladies the plant is ſubject to. Some of theſe maladies only attack the leaves, and produce on them ſpots of different colours, wrinkles, puſtules, ſcabs. Others attack the principal viſcera, and occaſion choakings, obſtructions, ſtagnations, tumours, cancers, effuſion. Others take their ſeat in the flower or fruit. Others affect the ligneous bodies, which they cauſe to moulder away, whilſt the barks remain whole.

Others

Others come from little plants or divers inſects, which being on the outſide or inſide of vegetables, convert their nouriſhment to their own advantage, or change the organization of it. Others derive their origin from a change of climate, aliment, or culture.

The laws of the nutrition and the growth of animals are more frequently diſturbed than thoſe of generation. From hence proceed the various ſpecies of diſorders to which an animal is expoſed. Among theſe maladies, there are ſome which attack only the ſkin, and produce ſpots of various colours, wrinkles, puſtules, pimples. Others attack the principal bowels, and occaſion oppreſſions, obſtructions, ſtagnations, tumours, abſceſſes, overflowings. Others are ſeated in the organs of generation. Others ſeize the bones, and beget rottenneſs in them, whilſt the perioſteum continues ſound. Others have their ſource from different inſects, which being lodged either without or within the animals, divert the nouriſhment of them to their own benefit, or alter the conſtitution of them. Others are cauſed by the change of climate, nouriſhment, or breeding.

13. Finally, the plant after having eſcaped a variety of maladies which threatened its life, cannot elude the effects of old age, that creeps into it, nor the ſtroke of death, the inevitable conſequence of it. Being hardened by time, the veſſels loſe their exerciſe, and are ſtuffed up. The liquors contained in them no longer move with the ſame facility, nor continue to be filtrated and pumped out with the ſame preciſion.—They ſtagnate and corrupt; and this corruption being ſoon communicated to the veſſels that encloſe them, the vital functions ceaſe, the plant dies and crumbles into duſt.

Laſtly, the animal, after having been preſerved from thoſe diſeaſes which conſpired againſt him, cannot eſcape old age, nor death that follows in his train.

When the veſſels are grown hard through time they loſe their action, and are ſtopped up. The liquors do

not circulate in them with the ſame degree of quickneſs, and they are filtered and pumped up but in a very imperfect manner. They ſtand ſtill and are altered, and this alteration ſoon communicating itſelf to the veſſels that contain them, circulation ceaſes, the animal dies, and is reduced to duſt.

14. We have carried the parallel between plants and animals from their birth to their death. The parts of which they conſiſt very evidently eſtabliſh the great analogy there is betwixt theſe two claſſes of organized bodies.

But there are other ſources of compariſons we have either avoided to dwell upon, that we might not render our deſcription confuſed, or have only ſlightly touched upon; under certain points of view. Such are thoſe preſented to us by place, number, fecundity, form, ſtructure, circulation of liquors, loco-motive, faculty, feeling, and nutrition.

We will take a tranſient ſurvey of theſe ſources, and without endeavouring to exhauſt them, content ourſelves with barely pointing out their moſt remarkable and characteriſtical contents.

Vegetables and animals reſide in the ſame dwelling-place. Being appointed to people and adorn our globe, they are diſperſed over its whole ſurface, and are placed near each other, in order to enable them to afford a reciprocal aſſiſtance. Like two great trees growing in the ſame ſoil, the animal and vegetable kingdoms entwine their branches together and extend their boughs and roots to the extremity of the world.

The outſide and inſide of the earth, mountains and vallies, barren and fertile places, countries undiſcovered and hid in dark obſcurity, the regions of the north and ſouth, rivulets, rivers, ponds, lakes and ſeas, have their vegetables and animals.

Many ſpecies of plants and animals ſeem to thrive alike in different climates. Other ſpecies are amphibious, and live as well out of the water as in it. The

bulruſh

bulruſh and frog flouriſh in meadows, and at the bottom of ponds. Others are paraſites, and are nouriſhed by the juices they extract from different ſpecies. Such are the miſſeltoe and the louſe.

Laſtly, Some paraſite ſpecies ſupply their neceſſities, in their turn, from other paraſites. The miſſeltoe has his liverworts, and certain lice have their lice.

15. There are upwards of twenty thouſand ſpecies of plants known to us, and new diſcoveries of them are made every day. A microſcopical botany has extended the dominions of the ancient. Moſſes, muſhrooms, liverworts, whoſe families are innumerable, now take place amongſt vegetables, and preſent the curious with flowers and ſeeds which before they were unacquainted with. The microſcope diſcovers plants to our view, where we never ſuſpected them. Free-ſtone is often covered with ſpots of different colours, commonly brown or blackiſh. Glaſs, notwithſtanding its fine poliſh, is not exempt from ſuch ſpots. We obobſerve hoarineſs on almoſt all bodies. Theſe ſpots and this hoarineſs are found to be gardens, meadows, and foreſts in miniature, whoſe plants that are infinitely ſmall, afford us neverthelefs ſome proſpect of their flowers and ſeeds.

But although vegetables are very numerous in their ſpecies, yet they are much leſs ſo than animals. Every ſpecies of plant has not only its particular ſpecies of animals, but there are many ſpecies of plants which nouriſh ſeveral ſpecies of animals. The oak alone finds nouriſhment for above 200 ſpecies of them. Some attack the roots of this tree, which they dig into, and produce therein various tuberoſities. Others fix themſelves in the trunk, where they make crooked furrows. Some inſinuate themſelves into the bark and wood; whilſt others penetrate the interior parts, whence they extract the juice. Some feed only on the leaves. Others fold or roll them up with a great deal of art. Some form them into nuts. Others find both lodging and nouriſhment in the fruit. Nay, gather but a flower by chance either a daiſy, poppy, or roſe, and you will obſerve on it a multitude of inſects.

In ſhort, where can we turn our eyes without beholding animals? Nature has ſtrewed them every where with a bountiful hand. They were her moſt excellent productions; ſhe has been liberal of them. She has encloſed animals within animals; ſhe has ordained one animal to be a world for others, which ſhould find therein nouriſhment in proportion to their wants. The air, vegetable and animal liquors, corrupt matter, dirt, dung, dry wood, ſhells, and even ſtones, are all animated, all ſwarm with inhabitants. What do I ſay? The ſea itſelf ſometimes appears to be one entire collection of animals. The light, which glitteringly reflects on it in the night-time during hot weather, is produced by an infinite number of very minute glow-worms of a yelloviſh brown colour, and ſoft ſubſtance, not unlike caterpillars, every part of which, after being divided, and even putrified, ſhines with the ſame brightneſs as when the worm was whole and living. A ſpecies of ſea-flies are alſo luminous, and communicate their luſtre to the waters. There iſſues from within them a globular matter, which is likewiſe phoſphorus.

Herbs are more numerous in their ſpecies and individuals than ſhrubs and trees. Inſects are more numerous, in reſpect to their ſpecies and individuals, than birds and quadrupeds. There are more ranunculuſes than roſe-buſhes, and more blades of graſs than oaks. There are more butterflies than fowls, and more vine-fretters than dogs.

16. The magnificence of the creation ſhines in no part of it with greater luſtre, than in the prodigious fecundity of a great number of plants and animals.—One ſingle individual may give birth to thouſands, or even millions of individuals like itſelf. Being formed agreeable to thoſe proportions which are only known to that Adorable Wiſdom that has eſtabliſhed them, this great people was at firſt encloſed within the narrow compaſs of a rind or ovary. In this dark abode they receive their firſt life, begin to grow, and are diſpoſed to appear on the vaſt theatre of the viſible world.

If

If we conſider things in a general view, vegetables will be found to be more fruitful than animals. We ſhall be farther convinced of this, by comparing trees with quadrupeds.

Trees produce annually, ſometimes for many ages, and their productions are always very numerous.—Large quadrupeds, as the elephant, the mare, the hind, the cow, &c. have ſeldom more than one at a time, rarely two, and the number they breed is always very moderate. Leſſer quadrupeds, ſuch as the dog, the hare, the cat, the rat, increaſe in a much greater degree; but their fecundity is but inconſiderable, when compared to that of the ligneous plants. The elm produces yearly upwards of three hundred thouſand ſeeds; and this aſtoniſhing multiplication may continue above a century.

Fiſhes and inſects nearly reſemble vegetables in fecundity. A tench lays about ten thouſand eggs: a carp, twenty thouſand: and a cod a million. An inſect which produces the itch, lays four or five thouſand eggs; a female bee, forty-five or fifty thouſand.

To this amazing fecundity is oppoſed that of the wild poppy, muſtard, fern. And we muſt not forget, that moſt vegetables are propagated different ways; whereas animals are for the moſt part propagated only by one.

A tree may be made to form as many trees as it has branches, boughs, and even leaves. Plants which are principally deſigned to ſupply the neceſſities of animals, cannot be endued with too great a degree of fecundity.

17. There is hardly any ſight more intereſting, than that which the infinitely varied forms of plants and animals afford. If one compares the leſs perfect ſpecies with the more perfect, or the ſpecies of the ſame claſs with each other, he is equally ſtruck with the diverſity of models, by which nature has performed her works in the

the vegetable and animal kingdoms. He paſſes with aſtoniſhment from the ſwinebread to the ſenſitive plant, from the muſhroom to the carnation, from the night-ſhade to the oak, from the ivy to the fir-tree. He conſiders with ſurpriſe the prodigious multitude of muſhrooms and liverworts, and can never enough admire the fecundity of nature in the production of theſe plants.

As he goes on to plants that are more elevated in the ſcale, he ſtops with pleaſure to examine thoſe plants that have ſtalks, from the graſs which grows between the ſtones to that precious plant, whoſe ear furniſhes us with the moſt wholeſome food. He conſiders the various plants that creep, from the tender bind-weed to the vine branch which crown our hills. He likewiſe takes a ſurvey of thoſe trees which bear fruit with ſtones, from the wild plumb-tree to the peach, whoſe fruit does not excite our admiration more by the ſoftneſs of its velvet covering and beautiful colour, than by the abundance and exquiſite taſte of the liquor it yields.

If from the vegetable, he tranſports himſelf into the animal kingdom, the proſpect becomes ſtill more intereſting. He ſees oppoſed to each other in the ſame portrait, the polypus and ſea-dog, the day-fly and flying-fiſh, the dancing bird and eagle, the graſshopper and flying-ſquirrel, the ant and ſtag, the cricket and rhinoceros, the wood-louſe and crocodile, the ſcorpion and the ape.

Another picture preſents him with a view of the prodigious number of butterflies and flies; in conſidering which, he is aſtoniſhed at Nature's complaiſance in thus diverſifying theſe little animals, ſo different from the great ones by their forms, and which have been treated as defective or imperfect beings.

Transferring next his ſurvey to thoſe ſpecies of animals immediately higher, he contemplates ſhell-fiſh, from that whoſe precious liquor dyes the garments of kings, to the ſailor that rows with ſo much grace and

ſkill

ſkill on the inconſtant wave. He obſerves the different ſpecies of fiſh, from the dangerous cramp-fiſh to the powerful nerval, and from the pretty golden-fiſh of China to the dolphin, that cleaves the billow with the ſwiftneſs of a dart.

He likewiſe takes a review of thoſe birds that live on herbs or ſeeds, from the linnet, that delights us with his melody, to the peacock that pompouſly diſplays in our court-yards the gold and azure with which he is enriched. He alſo obſerves the birds of prey, from the fierce merlin to the eagle, whoſe ſtrength and courage have raiſed him to the ſovereignty over the birds. He next reviews the quadrupeds, from the light and timerous hare to the elephant, whoſe enormous corpulency attracts every eye, and from the wily fox to that noble and generous quadruped which ſeems formed to have dominion over the animal creation.

Plants, though prodigiouſly various in their forms, yet are leſs ſo than animals. There are fewer gradations from the truffle to the ſenſitive plant, or from the night ſhade to the oak, than there are from the oyſter to the oſtrich, or from the ſea-nettle to the oran-outang. Plants, being eſſentially more ſimple than animals, have not given birth to ſo many combinations.

The forms of animals afford us a ſingularity which is extremely remarkable, and ſufficient to diſtinguiſh them from vegetables; I mean, thoſe admirable metamorphoſes which the ſame inſects exhibit to us, which are ſometimes ſo oppoſite, that it does not appear to be the ſame animal.

But may we not compare the bud in which a plant or flower is infolded, to the covering of a chryſalis which conceals the butterfly from our ſight? And as the plant cannot produce ſeeds till the flower has iſſued from the bud, ſo neither can the butterfly propagate till it has caſt off the ſheath of the chryſalis.

18. It is not ſo eaſy to compare plants and animals in their interior forms or ſtructure, as it is in their exterior. We may judge of the one by a ſingle glance of the eye: we muſt beſtow a particular attention, to judge of the other. We penetrate with greater difficulty, into the inſide of a plant, than into that of an animal. The microſcope, ſcalpel, and injections, which are ſo ſerviceable to us in the anatomy of animals, aſſiſt us very imperfectly in that of plants. It is likewiſe true, that this part of organical œconomy has been leſs ſtudied.

But how imperfect ſoever the anatomy of plants may be, we are able to diſcover ſome of their principal veſſels. Theſe may be ranged under two general claſſes; the longitudinal that extend the whole length of the plant; and the tranſverſe veſſels, or ſuch as are placed acroſs it. The ſappy veſſels and trachœan belong to the firſt claſs; the utriculi or inſertions to the ſecond. The veſſels containing the ſap ſeem deſigned to convey the juice. The utriculi, or little bags, appear intended for digeſting it.

Some plants ſeem to be entirely compoſed of utriculi: ſuch are certain ſpecies of roots and ſea-plants, whoſe texture is almoſt together veſicular. It is the ſame with thoſe animals which ſeem to conſiſt of ſtomach only, as the polypus and tape-worm.

One of the principal characters by which we may diſtinguiſh inſects from large animals, is, that the former have no bone within them. What they have of a bony or ſcaly nature is placed on their outſide for a ſupport or defence to the more delicate parts underneath, or to ſuſtain the body with greater advantage. Thus we ſee that in almoſt all inſects, properly ſo called, the head, corſlet, legs, rings, &c. are either wholly, or for the moſt part doubly covered with ſcales.

Herbs differ from trees as inſects from large animals. They have no ligneous body in their centre. What they have of a ligneous nature, appears on the

outſide,

outſide, and ſerves to protect the weaker parts of the plant. Thus we find plants with tubes are ſtrengthened by knots placed at regular diſtances; ſo that the lowermoſt knots which are deſigned for the baſe, are ſtronger and nearer each other than the upper ones. It is on the ſame account that the roots of many herbaceous plants, as well as the calixes of flowers, and the capſules or coverings of the ſeeds, are made almoſt ligneous.

Herbs grow and become hard ſooner than trees. Inſects than great animals. Herbs and inſects, being of a ſofter conſiſtence than trees and large animals, extend themſelves with greater eaſe, and ſooner arrive at the period of their extenſion. Beſides, the concentric beds of the bark of trees, and thoſe of the perioſteum of animals, being far more numerous than the relative beds of herbs and inſects, muſt needs require a longer time for their growth.

We may diſtinguiſh two kinds of parts in organized bodies; to wit, ſimilar and diſſimilar. The former are compoſed of fibres of the ſame kind; the latter, of fibres of various ſorts. The nerves, arteries, veins, lymphatic veſſels, are the ſimilar parts of our bodies; the brain, heart, lungs, ſtomach, the diſſimilar. Plants are almoſt entirely compoſed of ſimilar parts. The veſſels containing the ſap, the trachœa, and utriculi, are of this kind. Theſe different veſſels are pretty uniformly diſperſed throughout the whole body of the plant: they enter into the compoſition of all its parts. They are to be met with in the root, ſtalk, branches, leaves, flowers and fruits. The leaſt fragment, the ſmalleſt leaf, is a repreſentation of the whole, an abridgement of the plant.

There are likewiſe animals which are nearly compoſed of ſimilar parts. Of this number are many ſpecies of long worms, and ſome aquatic millipedes, nettles, and ſea-ſtars, polypuſes, moths, earth-worms. All theſe animals are formed in ſuch a manner, that each part of them, even the ſmalleſt, correſponds in miniature to the whole in all parts.

In the long worms I juſt mentioned, we obſerve very diſtinctly a ſtomach, a heart, and ſome very ſmall veſſels which ſeem dependent on the latter. There is likewiſe no room to doubt that there is beneath the ſtomach, a medullary ſtring, like that obſerved in other ſpecies of worms and caterpillars. Their viſcera are not diſtributed into certain regions of the body; they are univerſally diſperſed throughout its whole length; ſo that we may truly affirm that theſe inſects are all brain, all ſtomach, all heart. But this brain, ſtomach, and heart, appear extremely ſimple: the firſt is ſcarce any thing more than a nervous piece of net-work, the ſecond a membraneous bag, and the third a grand artery.

Polypuſes, which are more ſimple in their ſtructure, are only a kind of bowel, ſown with an infinite number of ſmall ſeeds, which are tinged with the colour of the aliment.

Tape-worms partake of the ſtructure of polypuſes, but ſeem to be more compounded. They are formed of a chain of flat, membraneous, and whitiſh rings, jointed together like the diviſions of a reed. Each ring has on its upper part, or on one of its ſides, a more or leſs ſenſible eminence, in the centre of which is a ſmall round aperture. The middle of the ring is full of veſſels of a purple or whitiſh colour, which perform a labour that attracts the attention of the obſerver. The reſt of the ring is filled with an infinite number of ſmall white ſeeds. Such is eſſentially the ſtructure of the tape worm in its whole extent; there is no perfect variety of reſemblance between all the rings, the aſſemblage of which compoſes a kind of ribband or lace, which extends ſometimes ſeveral hundred feet in length.

Earth-worms are, of all the inſects I have mentioned, thoſe whoſe inſide ſeems to be the moſt compounded, chiefly becauſe in them the two ſexes are united: but the moſt eſſential organs of life are diſtributed

tributed in them likewiſe through the whole length of the animal.

Organized bodies, whoſe ſtructure is ſo ſimple and uniform, that each part of them has in a ſmall compaſs an organization reſembling that of the whole in a greater extent, enjoy divers prerogatives that have been denied to organized bodies of a more complicated ſtructure. The firſt of theſe are not deſtroyed when divided aſunder. Their different portions continue to live, and the wounds which have been given to them eaſily conſolidate. Theſe parts vegetate, receive nouriſhment, produce new organs, and multiply. Such wonders as theſe the vegetables and inſects we have lately treated of exhibit every day: wonders which we have not ſufficiently admired in the former, and which perhaps we too much admire in the latter.

Large animals do not furniſh us with the ſame phenomena. The conſolidation of their wounds, and the re-union of their fractures, although oftentimes attended with circumſtances which render them very remarkable, ſtrike us but ſlightly when compared with what we obſerve analagous in polypuſes, and other inſects that multiply by ſlips. The motions we perceive in certain parts of great animals, when ſeparated from the body, or after the death of the animal, affect us only with a ſlender degree of ſurpriſe, when we conſider the motions of different parts of worms, or thoſe of ſome millepedes.

But may there not be ſome miſconception in theſe different judgments? We judge of the effect produced, as conſidered in itſelf, and ſeparate from the circumſtances accompanying it; whereas we ſhould judge of it with relation to the greater or leſs degree of compoſition whereof the body, in which this effect is produced, conſiſts. There is as much, and indeed more to be admired in the conſolidation of certain wounds, or in the re-union of certain fractures of our body, than there is in the conſolidation of the wounds of polypuſes, or in the re-union of parts which have

been

been ſeparated from them. A very ſimple machine is eaſily repaired; a machine that is extremely compounded, cannot be repaired with the ſame facility. When we reflect on the prodigious number of ſimilar and diſſimilar parts contained in the compoſition of the bodies of great animals, and particularly in that of the human body; when we attend to the ſtrict connection of all theſe parts, and to the degrees of compoſition in each of them, we cannot ſufficiently wonder that the various accidents which happen to theſe bodies are not attended with greater conſequences: we ſhall at the ſame time perceive the reaſon why they are not enabled to propagate like bodies whoſe organization is more ſimple.

But independently of the greater or leſs degree of the compoſition of parts neceſſary to life, as ſoon as theſe parts are found placed in different regions of a body, and are not diſperſed throughout its whole length, ſuch a body cannot be multiplied by ſlips. The Author of Nature, by denying, in his wiſdom, this property to large animals, by confining the ſources of life in them within a narrow circle, has ſecured them from harm by many advantages. Compare the reſult of the motions or actions of a ſea worm with that of the motions or actions of an ape, and you will ſoon perceive which of theſe animals has been moſt favoured.

Finally, organized bodies, to which a power has been granted of multiplying by a method which ſeems to tend to their deſtruction, are ſuch as are expoſed to the greateſt dangers, and whoſe life is neceſſarily threatened every moment with a thouſand various accidents.

19. Amongſt the motions we obſerve in the animal machines, that of the circulation holds the firſt rank, either by its importance, or its nature, duration, and the number of organs by means whereof it is performed. There is in this motion an air of grandeur that ſeizes forcibly on the mind, and which, by making

it

it ſenſible of the narrow limits of human underſtanding, penetrates it with the moſt profound reſpect, and fills it with the higheſt admiration of the Infinite Mind which illuſtriouſly ſhines in the Divine Author of it.

In the centre of the breaſt, between two ſpongy maſſes known by the name of lungs, is depoſited a fleſhy pyramid, whoſe baſe bears two ſmall funnels like ear-rings, which communicate with two cavities contained in the inſide of the pyramid, and which divide it according to its length into two chambers or ventricles, the right ventricle and the left. This pyramid is the heart, the main ſpring of the machine. It has two principal orders of muſcular fibres; ſome of which paſs obliquely from the baſe to the point, others cut the latter tranſverſely. From the exerciſe of theſe fibres two oppoſite motions reſult; one of dilatation, the other of contraction. The heart ſeems to execute theſe motions by turning on itſelf like a ſcrew. Its point moves towards or from the baſe, by riſing or falling obliquely.

Two great veſſels, viz. an artery and a vein, communicate with each ventricle. The artery *, which communicates with the right ventricle, conveys the blood to the lungs. The vein †, which communicates with the ſame ventricle, forms the principal trunk of the veins, and carries back the blood from all parts to the heart. The artery ‡, which goes into the left ventricle, is the chief trunk of the arteries, and that which conveys the blood to all parts. The vein §, which ends at the ſame ventricle, tranſmits to it the blood that has been conveyed from the lungs.

The principal trunks of veins and arteries, are divided into ſeveral branches at a ſmall diſtance from the heart. Some tend towards the upper extremities, others towards the inferior.

The arteries and veins decreaſe in diameter, and are ramified more or leſs according to their diſtance from their origin. There is no part to which theſe do not diſtribute one or more ramifications.

* The pulmonary artery. † The vena cava. ‡ The grand artery, or the aorta. § The pulmonary vein.

When

When they have arrived at the moſt remote parts, the arteries have an intercourſe with the veins.

The arteries are compoſed of ſeveral membranes, placed on each other. The veins have ſimilar membranes, but more ſlender, and weaker. The veins were not deſigned to exerciſe the ſame power as the arteries. Theſe latter muſt neceſſarily, like the heart, and for the ſame end, dilate and contract themſelves: they have therefore been provided with a very elaſtic membrane. The exerciſe of the veins ſhould not be violent.

At the root of the arteries, and in the inner part of the veins, are placed little ſluices or valves, which by ſinking and riſing again open and ſhut the canal. Theſe valves are depoſited in the veins, in a contrary ſenſe from that for which they are in the arteries. We ſhall preſently account for the cauſe of this difference.

20. After having been maſticated and diſſolved in the mouth and ſtomach, the aliment deſcends into the inteſtines, where it receives a new preparation by the mixture of two liquors, one of which is furniſhed by the liver, and is called the bile; and the other by a ſpecies of gland * ſituated under the ſtomach.

The aliment is thus converted into a kind of greyiſh pulp, which has received the name of chyle. Being ſhifted from place to place by the vermicular or periſtaltic motion of the inteſtines, and ſtrongly preſſed againſt their ſides at the inſtant of their contraction, the chyle penetrates into extreme ſmall veſſels †, which open themſelves in the internal membrane of the inteſtinal canal. Theſe veſſels tranſmit the chyle to very ſmall glands which are covered with a kind of membrane ‡ ſituated in the midſt of the inteſtines, and round which they are in a manner rolled. After being filtrated in theſe glands, the chyle is received by other veſſels §, which convey it into a concavity ‖ placed along the ſpine, and which pours it into a vein ſituated

* The pancreas and pancreatic juice. † The primary lacteal veins. ‡ The meſentery and meſenteric glands. § The ſecondary lacteal veins. ‖ The thoracic duct.

under

under the left clavicle. There it enters into the blood, and loſes the name of chyle. From this vein the new blood paſſes into the upper branch of the principal trunk of veins, which carries it towards the heart. It paſſes into the right lobe, which opens at its approach, and by cloſing immediately, forces it into the right ventricle, which is dilated in order to receive it. The heart inſtantly contracts itſelf; the valves with which the ventricle is furniſhed, raiſing themſelves to oppoſe the reflux of the blood into the lobe, it is compelled to paſs the artery, which is appointed to carry it to the lungs. The valves, which are placed at the entrance of this artery, ſink down; the artery dilates, and the blood advances into the cavity. The valves riſe again, and prevent its return towards the heart. The artery contracting itſelf, the blood is impelled farther, and, by theſe alternate dilatations and contractions of the veſſel, it is conveyed to the lungs, where it runs through every part of them. The ramifications of the trachœ *, which are diſperſed in the viſcera, carry thither a freſh and elaſtic air, which, by acting on the lungs, dilates, winds them about, extends and opens them, and by that means facilitates the courſe of the blood into the ſmalleſt ramifications of the artery. Beſides, being impregnated with this air, the blood becomes thereby attenuated, is cooled, and receives a more lively colour. After its arrival at the extremities of the artery, it paſſes into that of the pulmonary vein, which conducts it to the left ventricle of the heart. This latter, by contracting itſelf, puſhes it into the aorta †, which by continually dividing and ſubdividing itſelf, diſtributes this balſamic liquor to all the parts, in order to promote their growth, or ſupport, and occaſion different ſecretions.

21. Such is the admirable mechaniſm of the circulation of the blood in men, and in thoſe animals which we are beſt acquainted with. But how greatly does this imperfect ſketch fall ſhort of the reality! How incapable are theſe outlines of expreſſing the beauties

* The bronchia. † The principal trunk of arteries.

of

of this noble ſubject! And who can account for the manner by which the ſtrength of life is repaired and recruited? Who can conceive the cauſe of that perpetual motion of the heart, which continues without intermiſſion for the ſpace of ſeventy, eighty, or a hundred years, which has laſted for ages in the firſt race of men, and which remains almoſt as long in ſome ſpecies of animals? Have we diſcovered the exact part where the artery is changed into a vein? Have we diſcloſed the myſtery of the ſecretion of thoſe ſpirits, whoſe prodigious ſubtility and activity give them a near reſemblance to light? Can we even determine in what manner the groſſeſt ſecretions are performed? Do we underſtand the true mechaniſm of muſcular motion? Have we been able to find out the ſource of that great ſtrength which often ſo far exceeds that of the heart? All theſe dependencies on circulation are yet unrevealed to us. The gloom of night ſtill wraps theſe regions in dark obſcurity, and you are earneſtly deſirous of chaſing it away from before that ſun which alone can diſpel theſe ſhades. Will the dawn of that day ere long gild the horizon of the learned world? Or is the time of its breaking forth upon us yet afar off?

But if we are not able to diſcover the whole, we may at leaſt ſee enough of it to excite our admiration; and the ſketch which I have juſt drawn of the circulation, is ſufficient to enable us to conceive the higheſt ideas of the Sovereign Mind, which has appointed the manner, duration, and end of it.

Far leſs magnificent in its plans, leſs ſkilful in the execution of them, hydraulics offer to us but faint images of this miracle, in thoſe machines by means of which water is raiſed above the mountains, in order to its being diſtributed into every quarter of a great city, and made to circulate and iſſue forth, under a hundred various forms, into thoſe gardens which art and nature vie with each other in adorning and embelliſhing.

The works of the Creator muſt be compared with the works of the Creator. Ever like Himſelf, He has impreſſed on all his productions a character of nobleneſs and excellence, which demonſtrates the grandeur of their origin. From that immenſe maſs of water which encompaſſes the great continents, there inceſſantly ariſes an ocean of vapours, which, being rarefied by the combined action of the ſun and air, ſpread themſelves in the upper region of the atmoſphere, where they remain ſuſpended in equilibrio, being intermixed with the fluid in which they float, and gravitate with it. Collected afterwards into clouds more or leſs denſe, and borne on the wings of the winds, they fly acroſs the celeſtial plains, which they adorn with their rich colours, and continually variegated forms. Fixed at length on the mountain tops, they pour upon them abundant rains, which being collected in the vaſt reſervoirs, embóſomed within them, furniſh, by a happy circulation, a ſupply to fountains, rivers, lakes and ſeas. Like veins and arteries, the rivers flow meandering, and branching on the ſurface of the earth, they run through immenſe countries; water, fertilize, and unite them by a reciprocal commerce, and majeſtically rolling their waves toward the ſea, plunge themſelves into it, in order to be again exhaled in vapours, and re-enter afreſh into the channels of this magnificent circulation.

22. Does the ſap circulate in plants as the blood circulates in animals? Is this new mark of analogy between theſe two claſſes of organized bodies as real as it has appeared to be? Small bladders full of air which have been thought to be diſcovered within the leaves, have convinced us that they were the lungs of the plant.

But there have not been diſcovered in plants veſſels analogous to veins and arteries. No organ has been ſeen in them capable of performing the functions of the heart. A tree which is planted a contrary way, with the roots at top and the branches in the ground, lives, grows, bears fruit; from its roots, branches ſhoot forth, from its branches, roots. The ſame is obſerved

with

with reſpect to ſlips and layers. A young branch, or young fruit, after being grafted on a ſubject foreign to itſelf, incorporates with it, and derives from thence the ſame degree of growth it would have received from the plant whence it was detached. Experiments demonſtrate, that the motion of the ſap depends entirely on the alternatives of heat and cold, and the viciſſitudes of day and night. It is evident that the ſap riſes in the day from the roots to the leaves, and falls in the night from the leaves to the roots. In a word, the courſe of the ſap nearly reſembles that of the liquor contained in the tube of a thermometer. All is reduced to a ſimple counterpoiſe.

23. The nouriſhment of the more perfect animals requires to be more wrought than that of plants. Hence the neceſſity of the circulation of the blood. The preparations of the ſap do not require ſuch a punctual, regular, and conſtant motion; bare poiſings ſuffice. Large animals eat but at particular times: a preſſing ſenſation which induces them to take nouriſhment, does not continually act upon them. The different preparations their aliment ſhould undergo, would be diſturbed or interrupted, were a freſh ſupply to be received within them before the former was ſufficiently digeſted.

Plants, on the contrary, are in a ſtate of perpetual ſuction; they draw in nouriſhment continually, and in a very great quantity, in the day-time by their roots, in the night by their leaves. There is a plant which receives and tranſpires, in the ſpace of twenty-four hours, twenty times more than a man.

But if plants differ ſo much from large animals by circulation, on the other hand ſome ſpecies of animals ſeem nearly to reſemble plants by their want of this circulation. Not the leaſt appearance of this motion is to be perceived in the polypus, the tape-worm, the pond-muſcle, and divers other ſhell-fiſh.

24. One of the ancients defined a plant to be a rooted animal. He would undoubtedly have defined

an

an animal to have been a wandering plant. The locomotive faculty is one of thoſe characters which preſent themſelves firſt, when we compare the vegetable kingdom with the animal. We ſee plants that are conſtantly fixed on the earth. Being incapable of ſeeking their nouriſhment, it is ordained that this nouriſhment ſhall ſeek them. The greateſt part of animals on the contrary, are ſubjected to the care of providing their own ſubſiſtence. Nature has not always depoſited near them ſuch nouriſhment as was neceſſary for their ſupport. She has thought proper to oblige them to procure it for themſelves, often with much labour. And the different methods by which ſhe has inſtructed each ſpecies to obtain this end, much diverſify the ſcene of our world.

Whilſt the ploughman opens the earth, to entruſt with it the ſeeds neceſſary to ſupport him, the mole and the mole cricket are clearing for themſelves different routes, in the ſame, to ſearch for the food allotted to them. The huntſman purſues his prey with an obſtinate reſolution: triumphing in his ſwiftneſs and ſtrength. At other times preferring craft he becomes maſter of it by laying ſnares for it. The tyger ruſhes on the fawn ſporting in the meadow. The cat watches motionleſs and ſilent, till the young mouſe iſſues forth from its retreat, that ſhe may dart upon it in a moment. Some ſpecies of animals, reſembling mankind by their prudence, lay up proviſions againſt a time of ſcarcity; build themſelves magazines, in which are obſerved ſuch juſt proportions, as to give us cauſe to doubt whether it was the workmanſhip of a brute, were we not convinced that this brute itſelf is the work of Sovereign Reaſon.

25. How great is the diſtance in this reſpect from the beaver and bee, to the gall or cochineal inſect, the oyſter, the ſea-nettle, and ſeveral other kinds of inſects and ſhell-fiſh? The gall inſect *, being confounded, by his immobility and form, with the tree on which he lives, contents himſelf with extracting its juice. Car-

* See vol. iii. chap. viii.

ried

ried by the wave to the ſea-ſhore, the oyſter remains fixed there, and all its motions conſiſt in opening and cloſing its ſhell. The ſea-nettle, and all the different polypuſes with pipes, being continually fixed to the ſame place, open and ſhut like a flower; extend and contract themſelves like a ſenſitive plant; ſtretch out arms, by means of which they ſeize inſects. This is their principal character, and the leaſt equivocal character of their animality.

Thus it appears that the loco-motive faculty is not more proper for diſtinguiſhing the vegetable from the animal, than thoſe other characters which we have before treated of. In the mean time, what can be more diſtinct in appearance than a plant is from an animal? Or what more eaſy to characteriſe in the ſight of the major part of mankind? But when once we are convinced that every thing in nature is ſhadowed over, we are not ſurpriſed at the difficulties we meet with in our attempts to diſtinguiſh beings. We expect to ſee the ſpecies enter again into each other; and confine ourſelves to the ſmalleſt latitude, or to that which is attended with the leaſt uncertainty. In this principle we will conclude the parallel: let us ſee whether feeling, and the manner by which animals and vegetables are nouriſhed, will furniſh us with any thing more characteriſtical.

26. If there be any faculty which ſeems peculiar to the animal, it is certainly that of feeling. Being united to an organized ſubſtance by ties which perhaps are known to God only, this ſoul compoſes with this ſubſtance a mixed being, a being which partakes of the nature of bodies, and of that of ſpirits. As a portion of matter, it is a machine which is admirable in its ſtructure, and on which corporeal objects act mechanically. As a ſpiritual ſubſtance, it is affected at the preſence of ſpiritual objects in a manner which does not ſeem to have any relation with that by which material ſubſtances act on each other. From the expreſſion of external objects on the machine, there reſults a certain motion in the machine. From this motion

there

there follows a certain ſenſation in the ſoul, which is ſucceeded by the re-action of the ſpiritual ſubſtance on the corporeal; a re-action which manifeſts feeling from without, and which is the expreſſion or ſign of it.

The various ſenſations in the animal may be reduced to theſe two general claſſes, pleaſure and pain, ſeparated from each other by degrees which are frequently inſenſible, and iſſuing from the ſame origin. The expreſſion of pleaſure and pain is not alike in all animals; becauſe the organs, by means whereof the ſoul manifeſts her ſentiments, are not the ſame in all.

There are ſpecies in which feeling is manifeſted by a greater number of ſigns; more varied, more expreſſive. What expreſſion for inſtance, is there in the air, the motions, and the various attitudes of an ape, a horſe, a dog, a cat? There is not much leſs expreſſion in birds than in quadrupeds. Fiſhes do not expreſs themſelves with the ſame clearneſs and energy; they form a dumb people, amongſt whom the language by ſigns is little practiſed: but the extreme vivacity of their motions ſeems in part to compenſate for their ſterility of expreſſion. Reptiles, ſhell-fiſh, and inſects, which are ſtill at a greater diſtance from us than fiſhes, expreſs to us their feelings in a more obſcure manner; but which, notwithſtanding, we can conceive to a certain degree, and often acknowledge to be very expreſſive.

On the contrary, we do not diſcover in the plant any ſign of feeling. All in that ſeems to be purely mechanical. Its life appears to be leſs a life than a ſimple duration. We cultivate a plant, or we deſtroy it, without experiencing any thing ſimilar to what we meet with when we cheriſh an animal, or put it to death. We ſee the plant ſhoot forth, grow, flouriſh and bud, as we perceive the hand of a clock to have paſſed over the points of the dial.

Theſe conſiderations lead us to conſider feeling as a character proper for diſtinguiſhing the vegetable from the animal.

27. Since

27. Since then the faculty of feeling furniſhes us but with a doubtful character for diſtinguiſhing the vegetable from the animal, which is that we ſhould have recourſe to with this view? I think we have exhauſted them all: we have at leaſt treated of them all in a curſory manner. But we have not examined them all under their various aſpects. There is one of them, which being conſidered in a certain point of view, may perhaps procure us what we have in vain ſearched for in the others.

We may now conſider the poſition of thoſe organs by which plants and animals receive their nouriſhment. Theſe organs in plants are the roots and leaves. Both of them are furniſhed with pores, by means of which they pump in the nutritious juice. Theſe pores terminate at ſmall veſſels, which tranſmit the juice into the inner part: or, rather, theſe pores are only the extremity of theſe veſſels.

Animals have organs which are entirely analogous to roots and leaves; I mean lacteal veins, or veſſels which anſwer the ſame purpoſe. Theſe veins open themſelves in the inteſtines, and pump the chyle into them, which they convey into the channels of circulation. An animal is then an organized body, which is nouriſhed by roots placed within him. A plant is an organized body which receives its nouriſhment by means of roots placed on its outſide.

Yet an animal which is nouriſhed by pores diſtributed on its outſide, renders this character ambiguous. The tape-worm ſeems ſuch an animal. It forms in the inteſtines a great number of plaits: and ſometimes entirely fills the capacity of this canal. Each of the rings that compoſe it, and whoſe length is rarely more than one or two lines, is pierced with a ſmall round aperture, by which one may ſee the chyle iſſue, which the worm is full of, and which conſtitutes its principal nouriſhment. If this aperture is a kind of ſucker, by the help of which the inſect pumps the chyle that ſurrounds

rounds it, this method of nouriſhing itſelf varies but little from that of plants.

But without ſeeking very far for examples of animals that are nouriſhed like plants, this is the caſe of all animals, whether oviparous or viviparous, whilſt they are encloſed in the egg, or in the belly of their mother. The umbilical veſſels may be conſidered in the egg or in the matrix, as roots which imbibe the nouriſhment. It is the ſame with reſpect to inſects that multiply by ſhoots. Whilſt the young one ſtill adheres to its mother, it is nouriſhed in a manner little different from that which is peculiar to branches. Animal grafts nearly reſemble vegetable in this particular.

Laſtly, the ſkin of the human body imbibes, like the leaves of plants, the vapours with which the air abounds: and although men draw in much leſs nouriſhment by this means than vegetables, it is nevertheleſs true that their ſkin and leaves have, in regard to this circumſtance a great affinity to each other. Perhaps we may be able ſome time or other to diſcover animals which are nouriſhed by their ſkin only, as certain plants are by their leaves.

28. Do we then in vain ſeek for a peculiar character whereby we may diſtinguiſh the vegetable from the animal? I perceive a new property, which will perhaps furniſh us with what we ſeek for.

A muſcular fibre contracts of itſelf on the touch of all bodies, whether ſolid or liquid. This property is known by the name of irritability. It has nothing in it common to ſenſibility. The parts which are moſt ſenſible are not irritable, and the parts which are moſt irritable, are not ſenſible. Neither ought we to confound irritability with elaſticity. A dry fibre is very elaſtic, and not at all irritable. Animals purely gelatinous are not elaſtic, and are notwithſtanding very irritable. In ſhort, the fibres of old men, though much more elaſtic than thoſe of infants, are much leſs irritable.

We

We have ſeen that the heart is a real muſcle. If we extract it from the breaſt, it will continue to move till it has loſt its natural heat. The heart of a viper or tortoiſe beats ſtrongly for the ſpace of twenty or thirty hours after the death of the animal. Water or air, when introduced into the ventricle, are ſufficient to reſtore to the heart the motion it has loſt.

The periſtaltic motion of the inteſtines is likewiſe owing to their irritability. But the following is what we ſhould not have guſſed at. If they are plucked haſtily from the lower belly, and cut into pieces, all theſe pieces will crawl like worms, and contract themſelves on the ſlighteſt touch.

So that not only every muſcle, but alſo every fragment of a muſcle, and even every muſcular fibre, contract themſelves more or leſs on being touched by any body whatſoever, eſpecially if that body be of a ſtimulating nature. And as the fibre contracts ſo it likewiſe recovers of itſelf, and this alternate exerciſe laſts for a time proportionable to the degree of irritability.

It is evident, from all the experiments that the vital parts are the moſt irritable. The heart is the moſt irritable of all, and next to that, the inteſtines and diaphragm.

The nature of irritability is unknown: we only judge of it by its effects. It probably reſides in the elaſtic fluid which is interſperſed between the lamellæ of the fibre. The nerves are not irritable; but if a nerve be pricked, the muſcle at which it terminates will contract itſelf. The nerves may then give motion to the muſcles; but they do not communicate an irritability to them which they are not poſſeſſed of themſelves; they only put it into action, and thus they are the miniſters of the affections of the ſoul.

Irritability then ſeems to be what conſtitutes the vital power in the animal; and this property has not been perceived in the vegetable. Is it not then the diſtinguiſhing character we ſeek for?

CHAP.

CHAP. XI.

Of the Industry of Animals.

1. HITHERTO we have ſcarcely conſidered animals in any other light than with reſpect to the organization, and the immediate and general conſequences of it. We will now contemplate their induſtry, which is ſtill more intereſting to us.

Some animals ſeem reducible to feeling only. Others have all our ſenſes, and riſe almoſt to underſtanding. The diſtance from the polypus to the ape appears enormous.

Imagination and memory are obſervable in divers ſpecies: imagination in their dreams; memory, in the recollection of ſuch things as have affected them. Places, perſons, animate and inanimate objects are traced out in their brain, and they act agreeably to theſe repreſentations.

The degree of knowledge in each ſpecies anſwers to the place it occupies in the general plan. The ſphere of this knowledge extends to all caſes which the animal may naturally meet. And if the animal happens to be drawn from his natural circle, and nevertheleſs is not entirely removed out of it, we may conclude that this new ſituation has a relation to one of the caſes to which the ſphere of his knowledge extends.

The way whereby animals vary their proceedings as neceſſity requires, furniſhes one of the ſtrongeſt arguments againſt the opinion which transforms them into mere machines. The philoſopher who attributes to them a ſoul, founds his judgment on the analogy of their organs with ours, and of their actions with ſe-

veral of ours. Thoſe who make the ſoul material, forget that even feeling is incompatible with the properties of matter.

The greater the number of caſes is to which the knowledge of an animal extends, the higher is this animal elevated in the ſcale.

The preſervation of life, the propagation of the ſpecies, and the care of their young, are the three principal branches of the knowledge of animals; but all are not alike to be admired in theſe reſpects.

The oyſter knows only how to open and cloſe its ſhell.

The ſpider ſpreads a net for his prey: waits like a huntſman, till ſome inſect falls into the ſnare: hardly has he touched it, before he darts upon it. Is he armed, or too nimble? He faſtens the lines to him with wonderful ſkill, and thus diſables it either from flying or defending itſelf.

Divers ſpecies of animals live from day to day, without taking any thought for the ſucceeding day. Others ſeemed endued with a kind of foreſight, conſtruct magazines with abundance of art, which they fill with various kinds of proviſions; ſuch as the bee and the beaver.

Among animals that live by prey, ſome, like the eagle and the lion, attack with open force. Others, as the hawk and the fox, join craft to ſtrength. Some ſave their lives by flight; others by hiding themſelves under the earth or water; while others ſtill have recourſe to divers ſtratagems to facilitate their flight, and evade the purſuit of their enemy.

Thoſe philoſophers, who take a great deal of pains to define inſtinct, are not aware, that in order to do it, they ſhould ſpend ſome time in the head of an animal, without becoming the animal itſelf. To ſay in general, that inſtinct is the reſult of the impreſſion of certain objects on the machine, of the machine on the ſoul, and of the ſoul on the machine; is to ſubſtitute terms that are a little leſs obſcure, inſtead of a very obſcure term: but the idea does not iſſue from the thick darkneſs

darkneſs that covers it. We well know what is not inſtinct, but are utterly ignorant what it is. It is not underſtanding, or reaſon. The brute has neither our notions, nor our mean ideas; becauſe it has not our ſigns.

2. At the ſame time that Nature has taught divers animals the method of attacking and purſuing their prey, ſhe has inſtructed them in that of ſelf-defence or eſcaping. If we were converſant in the books of nature, we ſhould there ſee, without doubt, that the profit always makes amends for the loſs. A regiſter of the births and deaths of ſome ſpecies puts this truth beyond all controverſy.

Thoſe ſpecies which multiply moſt, have the greateſt number of enemies. Caterpillars and vine-fretters are attacked as much within as without, by I know not how many inſects, that are always bent on deſtroying the individuals, without being able to effect the deſtruction of the ſpecies. Many ſpecies ſeek their living or retreat in the inner part of the earth, or in that of plants and animals. Others build themſelves neſts or ſhells with amazing art, where they paſs their time in weakneſs and inactivity.

Some that are more ſkilful, can, like us, make themſelves clothes, and even procure matter for their nouriſhment. They ſtrip our cloths and furs of their hairs, and make a kind of ſtuff of it, wherewith they clothe themſelves. The form of their dreſs is very ſimple, but very commodious. It is a ſort of muff or caſe, which they can lengthen or widen as they find occaſion. They lengthen it by adding to each end new layers of ſilk and hair, and widen it as we do a glove, by cutting it in the middle according to the length of it, and by engrafting a piece. You may imagine that I am ſpeaking of houſe-moths; field-moths, which clothe themſelves with leaves, ſurpaſs them in induſtry.

Several kinds of fiſhes and birds change, at a ſtated time, their dwelling-places. We have ſeen numerous ſhoals of herrings and cod-fiſh, and flocks of geeſe, quails, and crows, reſembling thick clouds, that ſometimes darken the air. By ſuch periodical emigrations

the ſpecies are preſerved, and in their long pilgrimages Nature is their pilot and provider.

3. The graſshopper, lizard, tortoiſe, and crocodile furniſh examples of animals that ſcarce take any care of their eggs, and are almoſt wholly unmindful of the young that are hatched from them. They lay them in the earth or ſand, and leave the ſun to communicate the warmth neceſſary for them. Shell-fiſh practiſe the ſame method: ſome ſpawn in the water; others between ſtones, or in the ſand.

The inſtinct of the different ſpecies conſiſts in depoſiting them in places where the young may find proper nouriſhment at their birth. The mothers commit no miſtake with reſpect to that. The butterfly of the cabbage-caterpillar never lays her eggs on meat, nor the fleſh-fly on the cabbage.

The gnat, that flutters in the air, was at firſt an inhabitant of the water. For this reaſon her eggs are always depoſited in the water. The maſs formed by them reſembles a little veſſel which the inſect ſets afloat. Each egg is in the form of a keel. All the keels are vertical, and are diſpoſed back to back. The gnat lays but one egg at a time. We cannot deviſe how ſhe can cauſe the firſt egg or keel to remain in the water. Her method is nevertheleſs very ſimple, but much more ingenious. She ſtretches out her long legs behind her, croſſes them, and by thus forming an angle of them, receives the firſt egg, and holds it at pleaſure. A ſecond egg is ſoon placed next the firſt; then then a third, a fourth, &c. The baſe of the pyramid thus widens by little and little, and at length is capable of ſuſtaining itſelf.

Some ſpecies glue their eggs with great ſymmetry and propriety round the branches or ſmall ſhoots of trees, like rings or circles. One would be apt to ſay, that ſome ſkilful hand had been diverting itſelf in fitting pearl bracelets on the ſprigs. A caterpillar, which, from the diſtribution of its colours, is called livery, transforms itſelf into a butterfly, that diſpoſes her

her eggs in this manner, and forms theſe pretty bracelets of them.

Other butterflies do ſtill more: they ſtrip themſelves of their hair, and make with it a kind of neſt for their eggs, where they lie ſoft and warm. Such in particular is the induſtrious workmanſhip of the butterfly, proceeding from that called the common caterpillar, becauſe it is in fact moſt common in theſe countries.

4. Certain ſpecies are ſo attached to their eggs, that they carry them about with them every where. The wolf ſpider encloſes her's in a little ſilk purſe, which ſhe bears on her hind-part. Does any one deſtroy it, or take it from her? Her natural vivacity and agility abandon her: ſhe ſeems to fall into a kind of languor. Has ſhe the happineſs to recover the precious truſt? She inſtantly ſeizes it, carries it away, and betakes herſelf to flight. As ſoon as the little ſpiders are hatched, they collect and arrange themſelves ſkilfully on the back of their dam, who continues for ſome time to beſtow her attention on them, and to tranſport them with her wherever ſhe goes.

Another ſpider lodges her eggs in a little ſilk purſe, which ſhe wraps up in a leaf. She fixes herſelf on this purſe, and ſits on her eggs with amazing aſſiduity. Another, to conclude, encloſes her's in two or three little ſilk balls, which ſhe ſuſpends by threads; but has the precaution to hang before, at a ſmall diſtance, a little bunch of dry leaves, to conceal them from the inſpection of the curious.

5 Divers ſpecies of ſolitary flies are not leſs to be admired, as well for their foreſight in amaſſing proviſions for their little ones, as for the art diſplayed by them in the neſts they prepare for their reception. The maſon bee, ſo called becauſe like us, ſhe underſtands the art of building, performs ſuch works in maſonry, as one would imagine muſt greatly ſurpaſs the ſtrength of a fly. With ſand, collected grain by grain, and glued together with a kind of cement much preferable to ours, ſhe erects a houſe for her family: a very ſimple one indeed, but extremely ſolid and commodious.

It is divided within into ſeveral chambers or cabins, on the back of each other, without any communication between them. One general foldage, a wall of encloſure comprehends them all, and leaves no opening without. This wall muſt be broke before the apartments can be ſeen, and it is found to be as hard as a ſtone. Theſe neſts are very common on the fronts of houſes: they there reſemble little oval hillocks, of a different grey from that of the ſtone. The fly that is the architect of theſe buildings depoſits an egg in each chamber, and ſhuts up in it at the ſame time a ſtock of wax or paſte, which is the nouriſhment appropriated to her young.

Another fly, which may be called the carpenter bee *, becauſe ſhe works in wood, likewiſe builds apartments for her family, but in a different taſte from that of the maſon. Sometimes ſhe diſtributes them into ſtages; ſometimes diſpoſes them in a row. Ceilings or partitions, artfully made, ſeparate all theſe ſtages or chambers, and there is an egg depoſited in each of them, with the quantity of paſte neceſſary for the young.

6. Theſe various kinds of work require in general leſs ſkill and genius than labour and patience. There is a very different degree of art and ſagacity diſplayed in the neſt conſtructed by another fly with ſingle pieces of leaves only. This neſt is a real prodigy of induſtry. When it is taken to pieces, and narrowly examined in all its parts, one cannot conceive how a fly ſhould be able to cut them out, turn, and put them together with ſo much propriety and exactneſs. When viewed on the outſide, this neſt very much reſembles a tooth-pick caſe. The inſide is divided into ſeveral little cells, in the form of a thimble, ſet in one another as thimbles are in a tradeſman's ſhop. Every thimble conſiſts of ſeveral pieces, which are ſeparately cut from one leaf, and whoſe form, circumference, and proportions tally with the place each is intended to occupy The ſame method is uſed with reſpect to the pieces that form the caſe or common cover. In a word,

* The wood-piercing bee.

there

there is ſo much exactneſs, ſymmetry, uniformity, and ſkill in this little maſter-piece, that we ſhould not believe it to be the work of a fly, did we not know at what ſchool ſhe learnt the act of conſtructing it. We may naturally conjecture that each thimble is a lodging for a little one; but we could not have imagined that the paſte which the mother provides for it is almoſt liquid, and that the little cell, which is entirely compoſed of ſmall pieces of leaves, is notwithſtanding a veſſel ſo well cloſed up, that this paſte never ſpills, even when the veſſel is ſtooped.

7. Many brutes act in concert with each other. A drove of oxen is grazing in a meadow: a wolf appears: they immediately form into a battalion, and preſent their horns to the enemy. This warlike diſpoſition diſconcerts him, and obliges him to retire.

In winter, hinds and young ſtags aſſemble in herds, in the more numerous companies as the ſeaſon happens to prove ſevere. They warm each other with their breath. In the ſpring they ſeparate, the hinds concealing themſelves in order to bring forth. The young harts remain together, love to walk in company, and are only parted by neceſſity.

Sheep that are expoſed to the ſultry heat of the dog-days in an open plain, keep near each other, ſo that their heads touch; they hold them inclined towards the earth, and ſnuff up the freſh air which comes from beneath them.

Wild ducks, that are accuſtomed to change their climate, range themſelves in their flight in the form of a wedge, or an inverted V, that they may cleave the air with the greater eaſe. The duck at the extreme point leads the flight, and cleaves the air firſt of all. After a certain time he is relieved by another, the ſecond in his turn by a third, &c. In this manner each bears a ſhare in the laborious part of this office.

8. Animals to whom the company of their own kind is uſeful, have been rendered fit for this commerce.

merce. And if the Author of Nature had man in view with reſpect to this particular, as we may without pride ſuppoſe, the means will be found to correſpond perfectly well with the end. In effect, how many embarraſſments and inconveniencies would have accompanied the divers ſervices we deduce from domeſtic animals, if individuals of the ſame ſpecies had not power to cohabit together!

The ſpirit of ſociety is not altogether limited to individuals of the ſame ſpecies, but extends likewiſe in a certain degree to thoſe of different ſpecies, and from thence man alſo derives ſome advantage. The cuſtom of ſeeing each other, of eating their meals in common, of repoſing under the ſame roof, confirms the natural diſpoſition of domeſtic animals to live in ſociety. The connections which reſult from it become ſo much the ſtronger, as they begin earlier or nearer to their birth. Thus animals that are not appointed to live together, may notwithſtanding form a ſort of ſociety: the natural inclination each of them has to live with thoſe of a like kind, is ſuſceptible of modification or extenſion.

Every individual knows his like; thoſe of the ſame ſociety likewiſe know them. It is obſervable, that if ſtrange fowls are brought into a poultry-yard, thoſe of the place will perſecute them, till cohabitation has made them members of the ſociety.

The outſide of the body exhibits divers characters, by means of which individuals of the ſame ſociety may know each other, and diſtinguiſh ſtrange individuals. But among theſe phyſical characters, there may be ſome mixed ones, or ſuch as belong as much to the ſoul as the body, which the animals of the claſs we are treating of, are capable of ſeizing; ſuch are the air, poſture, gait. The individuals of that ſpecies which are not yet become familiar in their new habitation, ſeem fearful or embarraſſed; this fear or embarraſſment detects them, and excites or encourages others to attack them.

That kind of ſociety in which domeſtic animals live, gives room for a remarkable obſervation; the young lamb diſtinguiſhes her mother from amongſt 3 or 400 ſheep,

ſheep, although there does not appear to be any ſenſible difference betwixt them.

9. Nothing is more wonderful than thoſe legions of flying creatures, that at a ſtipulated time paſs from one to other very remote countries. What inſtinct aſſembles them? What compaſs directs them? What chart points out their way? We preſently conceive that the change of the ſeaſon, and the want of ſuitable nouriſhment, advertiſe theſe different ſpecies of birds to ſhift their abode. But whence did they learn that they ſhould meet with in other regions a climate and aliment proper for them? In order to be able to anſwer theſe queſtions, and all ſuch as may be aſked on this intereſting ſubject, we ſhould carefully examine every circumſtance that attends the marches of theſe birds. The degree of cold or heat that accelerates or retards them, deſerves to be particularly attended to; for there is no room to doubt that they are moſt of all influenced by this. There is perhaps a ſecret relation between the temperature which ſuits with certain ſpecies, and that which is neceſſary for the production of the food that nouriſhes them.

But we have not carried our inquiries deep enough into theſe different ſpecies of birds and fiſhes of paſſage.

10. Among the ſocieties of brutes improperly ſo called, ſome depend on chance, or on the agency of men, if not altogether, at leaſt in part. It is not ſo with reſpect to ſocieties properly ſo called. They do not owe their origin to any human act, but ſolely to nature. The members that compoſe them are not only united by common neceſſities, and that for a ſhort time; but they are ſo by a much ſtronger tie, which ſubſiſts to the death of the animal, or at leaſt during a conſiderable part of its life; I mean, the natural preſervation of the individual, or that of its family. Both the one and the other are neceſſarily attached to the ſtate of ſociety. It is for this great end that theſe different ſpecies of ſocial animals have been inſtructed to labour in common on works ſo worthy of admiration.

Societies properly ſo called may be divided into two claſſes: the firſt comprehends thoſe whoſe principal end is limited to the preſervation of individuals; the ſecond, thoſe whoſe ſcope is, the preſervation of individuals, and education of their young.

Several ſpecies of caterpillars and ſome ſpecies of worms belong to the former of theſe two claſſes; ants, waſps, bees, beavers, to the ſecond.

The firſt claſs will have under it two principal ſorts; one of which will comprehend temporary ſocieties; the other, ſocieties for life.

11. A butterfly depoſits her eggs, about the middle of ſummer, on the leaf of a plumb-tree; the number of theſe eggs is three or four hundred. After ſome days, there iſſues from each of them a very ſmall caterpillar. They are ſo far from diſperſing themſelves on the adjoining leaves, that they all continue together on that whereon they firſt received their being: the ſame ſpirit of ſociety unites them. They apply themſelves immediately in concert in the ſpinning of a web, which at firſt is very thin, but they afterwards make it ſtronger, by gradually adding new threads to it. This web is a real tent ſpread upon the leaf, under which the young caterpillars ſhelter themſelves. As they increaſe in bulk, they extend their lodging by freſh layers of leaves and ſilk. The ſpaces contained between theſe layers are apartments, all of which communicate by doors made on purpoſe. In this neſt they paſs the winter, placed near each other, without motion, till the returning ſpring enlivens them, and invites them to brouze on the ſprouting leaves. Laſtly, towards the month of May, the ſociety is diſſolved; every caterpillar ſeparates from his companion, and ſpends the remainder of his life in ſolitude. Being then become ſtronger, a ſtate of ſociety is no longer neceſſary for them.

12. The caterpillars, that live on the oak, and whoſe ſocieties are much more numerous than thoſe of the common, are very ſingular in their proceedings. They ſet out from their neſt at ſun-ſet, and march in proceſſion,

proceſſion, under the conduct of a chief, whoſe motions they follow. The ranks are at firſt compoſed only of one caterpillar, afterwards of two, three, four, and ſometimes more. The chief has nothing in him that may diſtinguiſh him from the reſt, but by being the firſt, and that he is not conſtantly, becauſe every other caterpillar may in his turn occupy the ſame place. After having taken their repaſt on the leaves around them, they return to their neſt in the ſame order; and this continues during the whole life of the caterpillar. When they have arrived to their full growth, each forms for himſelf a cone, where it is transformed into a chryſalis, and afterwards aſſumes the form of a butterfly. Theſe metamorphoſes cauſe a new kind of life to ſucceed to the ſtate of ſociety, which is very different from the primitive one.

This is an example of ſocieties for life, whoſe principal end is the preſervation of individuals.

13. There are ſeveral kinds of caterpillars that are true republicans, and whoſe diſcipline, manners, and genius, diverſify them as much as thoſe of different people. Some of them, like ſavages, make themſelves hammocks, in which they take their meals, and even paſs their whole lives. Others live like the Arabs and Tartars, in tents, which they erect in the meadows; and when they have conſumed all the herbs that grew about them, they go away and pitch their camp elſewhere.

The neſts which the republican caterpillars make for themſelves are perfect retreats; they are ſcreened in them from the injuries of the air, and are all cloſely ſhut up in times of inaction or idleneſs. But they go out at certain hours to ſeek their nouriſhment. They feed on the leaves which ſurround them; which they conſume one after another. They often go to a great diſtance from their dwelling, and by different turnings. However, they can always find it again, when they have occaſion. Nature has provided them with a method for regaining their lodging, which anſwers exactly to that uſed by Theſeus for fetching Ariadne out of the labyrinth. We pave our ways; our caterpillars

line

line theirs with tapeſtry. They never walk but on ſilk carpets. All the paths that lead to their neſt are covered with ſilk threads. Theſe threads form tracks of a gloſſy white, which are at leaſt two or three lines in width. By purſuing theſe tracks in a row, they never loſe their way, how intricate ſoever the turnings and windings of their paſſage may be. By putting a finger on the track, we ſhould interſect the path, and throw the caterpillars into the greateſt perplexity. They ſtop on a ſudden at this place, and expreſs all the ſigns of fear and diſtruſt. Their march is ſuſpended, till ſome caterpillar, more bold than the reſt, croſſes over the ſpoiled path. The thread ſhe ſpreads in croſſing ſerves as a bridge for the next to paſs over. This in paſſing ſpreads another thread; a third another, and thus the way is ſoon repaired.

Yet there is a great difference between the method of the republican caterpillars, and that of Theſeus. They do not ſpread a carpet over their paths, to prevent their miſſing their way; but they do not miſs their way, becauſe they ſpread ſuch a carpet. They ſpin continually, becauſe they have always occaſion to evacuate the ſilky matter, which their nouriſhment produces again, and which is encloſed in their inteſtines. By ſatisfying this want, they are aſſured of being in the right path, without attending to it. The conſtruction of the neſt is likewiſe connected with this want. Its architecture is adapted to the form of the animal, to the ſtructure and exerciſe of his organs, and to his particular circumſtances.

14. Ants ſeek their proviſions and aliment at a great diſtance from their abode. Various paths, which are often very winding and intricate, terminate at their neſt. The ants paſs over them in rows, without ever miſſing their way, any more than the republican caterpillars. Like the latter, they leave tracks wherever they paſs. Theſe are not diſcernible to the eye; they are much more ſenſible to the ſmell; and it is well known that ants have a very penetrating one. However, if we draw a finger ſeveral times backwards and forwards

forwards along the wall by which the ants paſs and repaſs up and down in rows, they will be ſtopped on a ſudden in their march, and it will afford ſome amuſement to obſerve the perplexity they are in. It will happen in the ſame manner with regard to the proceſſions of theſe ants, as has been before related concerning thoſe of the caterpillars.

15. The ſight of a bee-hive is certainly one of the fineſt that can offer itſelf to our eyes. There appears in it an aſtoniſhing air of grandeur. One can never be weary of contemplating theſe work-ſhops, where thouſands of labourers are conſtantly employed in different works. We are ſtruck in a particular manner with the geometrical exactneſs of their works; as we likewiſe are at the ſight of their magazines, which are repleniſhed with every thing neceſſary for the ſupport of the ſociety during the rigorous ſeaſon. We likewiſe ſtop with pleaſure to behold the young ones in their cradles, and to obſerve the tender care of their nurſing mothers towards them.

But what chiefly attracts the attention, is the queen: the ſlowneſs, I had almoſt ſaid gravity, of her march, her ſtature, which is a more advantageous one than that of the other bees, and, above all, the various homage paid her by the reſt. We can ſcarcely believe what our eyes are witneſſes of, in the regard and aſſiduities of the neuters for this beloved queen. But our amazement is greatly heightened when we ſee theſe laborious, active inſects entirely ceaſe from their labour, and ſuffer themſelves to periſh, as ſoon as they are deprived of their ſovereign.

By what ſecret engagement, by what law ſuperior to that whereby each individual provides for its own preſervation, are the bees attached to their queen in ſuch a degree, as abſolutely to neglect the care of their own lives, when they happen to be ſeparated from her? This law ſeems to be nothing more than the grand principle of the preſervation of the ſpecies: the neuters do not engender; but they know that the queen enjoys that faculty: they conſtruct thoſe cells,

whoſe

whoſe proportions we ſo much admire, for the reception of the eggs ſhe is ready to lay. Nature has inſtructed them as much with regard to the young that is to be hatched from them, as ſhe has the mothers of other animals in favour of their offspring.

16. Of all animals that live in ſociety, none approach nearer to human underſtanding than beavers. We are at a loſs to determine what is moſt worthy of admiration in their labours, whether the grandeur and ſolidity of the undertaking, or prodigious art, fine views, and general deſign ſo excellently diſplayed throughout every part of their execution. A ſociety of beavers ſeem to be an academy of engineers, that proceed on rational plans, which they rectify or modify as they judge neceſſary, purſuing them with as much conſtancy as preciſion; all are animated by the ſame ſpirit, and unite their will and ſtrength for the promoting one common end, which is always the general good of the ſociety. In a word, we muſt be witneſſes of their performances, before we can judge them capable of them. A traveller that is ignorant of them, and happens to meet with their habitations, will think he is among a nation of very induſtrious ſavages.

The mole or bank which they raiſe, is a work of immenſe labour, and it is inconceivable how brutes are able to project, begin, and complete it. Repreſent to yourſelf a river of fourſcore or a hundred feet in width. Their firſt buſineſs is, to break the force of the current. The beavers then throw up a bank or cauſeway eighty or a hundred feet in length, by ten or twelve feet at its baſe. Nothing is more certain than this, nor leſs likely: and when we have repeatedly ſeen it, we are ſtill willing to renew our inſpection of it, in order to enforce our belief.

The moſt conſiderable towns of the beavers, conſiſt of twenty or twenty-five lodgments, though ſuch are but rare. The moſt common have only ten or twelve.

Each

Each republic has its peculiar diſtrict, and admits of no accidental gueſts.

When any great inundations damage the edifices of the beavers, all the ſocieties without exception unite together for making the neceſſary repairs. If hunters declare a cruel war againſt them, and entirely deſtroy their banks and cottages, they diſperſe themſelves about the country, betake themſelves to a ſolitary life, dig burrows or trenches under ground, and never ſhew any marks of that induſtry we have been admiring.

17. Beavers ſeem to be formed with a view to confound our reaſonings. Their aſſociating themſelves into great bodies, for working in concert on their immenſe works; their ſeparating into little families, or particular ſocieties, charged with the conſtruction of the huts; the nature of theſe works, their extent, ſolidity, propriety, and appropriation ſo conducive to one general end, comprehending ſuch a number of ſubordinations: in a word, their almoſt perfect reſemblance with works erected by men with the ſame intent; all concur to give the labour of the beavers an undoubted ſuperiority over that of the bees. In fact, to fell trees choſen on purpoſe, to lop them, and cut off their projections, to make great croſs pieces of timber of them, diſpoſing them in their proper places; to cut ſmaller trees like ſtakes, plant ſeveral rows of theſe ſtakes in a river, and interlace them with branches of trees, in order to ſtrengthen and connect them together; to make mortar, and with it ſolidly to compact the inſide of the pile: and to all this to add the form, proportions, and ſolidity of a great bank; to form ſluices thereon, and open or ſhut them according to the water's elevation or abatement; to build behind the bank little houſes one or more ſtories high, founded on an entire pile-work; to build them ſolidly without, and incruſt or cement them within by a layer of plaiſter, applied with equal exactneſs and propriety; to cover the flooring with a verdant tapeſtry; to contrive lights and outlets in the walls for different purpoſes;

to

to erect magazines, and ſupply them with proviſions; to repair with diligence whatever breaches may happen to the public works, and re-unite themſelves into one grand body for the effecting in common theſe reparations; are aſtoniſhing marks of induſtry, which ſeem to imply in the beavers a ray of that light, which raiſes man ſo far above the reſt of the animal creation.

CHAP. XII.

Continuation of the Industry of Animals.

1. WE ſhall in the next place treat of the proceedings of ſolitary animals. If they do not affect that extraordinary air of reflection and prudence, that brightneſs of genius, and that appearance of policy and legiſlation which we admire in ſociable animals, they nevertheleſs attract our regard, either by their ſimplicity and ſingularity, or their diverſity and appropriation to one common end, for the attaining of which they uſe the ingenious and natural means. After having contemplated the government, manners, and labours of a republican community, we may ſtill find ſome pleaſure in conſidering the life and occupations of a ſolitary one, thus paſſing from the monuments of Rome to the cottage of a Robinſon. Thoſe works that are performed by the ſociable animals, and which aſtoniſh us as much by their ſize, as by the beauty of their diſpoſition, reſult from the concurrence of a number of individuals. They all paſs through various hands: ſome ſketch them, others bring them to a greater perfection, and a third ſort finiſh them. The works of ſolitary animals ſpring from one head only; and the ſame hand that begins them, continues, finiſhes,

finiſhes, and repairs them. Each individual has his particular talent and degree of ſkill, whereby he provides for his own ſubſiſtence, and furniſhes himſelf with all neceſſaries.

We will here confine ourſelves to the proceedings relative to the metamorphoſis: this is an affair of great importance for one of our hermits to prepare himſelf for, the moſt intereſting to him of any during his whole life. Caterpillars alone exhibit to us the examples of almoſt all the proceedings which nature has taught to inſects of this kind. We will limit our examinations to this claſs in particular.

2. There are ſome caterpillars whoſe bodies are ſupported by a prop, and nature has taught them the method of effecting this. They wind a girdle round their body, compoſed of a number of ſilk threads collected together, whoſe ends are fixed to the prop that ſuſtains them. By this means they faſten their hind legs in a little heap of ſilk. It is eaſy to imagine after this, that the chryſalis muſt be tied and grappled as the caterpillar was. The girdle is looſe, and leaves the chryſalis ſufficient room to perform its little operations.

3. Other caterpillars form cones. Some of theſe give their cone a more exquiſite form, ſo as to reſemble that of an inverted boat. The cone of a ſilk-worm is made, if we may be allowed the expreſſion, of a ſingle piece. The cones made boat-wiſe conſiſt of two principal parts, ſhaped like ſhells, and joined together with great ſkill and propriety. Each ſhell is worked ſeparately, and formed of an almoſt infinite number of very minute ſilk rings. On the fore-part of the cone, which repreſents the hind-part of the boat, is a ledge that juts out a little, in which we may perceive a very narrow crevice, which denotes the aperture contrived for the exit of the butterfly. By means of that, the two ſhells may part aſunder, and leave room for the butterfly to paſs through them. They are conſtructed and put together with ſo much art, that they are of the nature of a ſpring, and the cone from whence the butterfly has lately iſſued appears as cloſe as that which

it

it ſtill inhabits. By this ingenious artifice the butterfly is always free, and the chryſalis in ſafety. We ſhall hereafter come to treat of proceedings which are analogous to theſe, but more ſingular.

4. Our ſpinners have not all an equal proviſion, yet all ſeem to endeavour at concealing themſelves from ſight. Such as are not rich enough to make themſelves a good lodgment of ſilk, ſupply the want of it by different matters of a coarſer or finer texture, which they are ſufficiently ſkilful to cauſe to contribute towards the conſtruction of the lodge. Some content themſelves with giving it a covering of leaves, which they connect together without any art. Others do not confine themſelves to the amaſſing theſe leaves, and diſpoſing them indiſcriminately; but range them with a kind of regularity. Others think proper to powder the whole of their cone with a matter they yield from behind them, and which they cauſe to penetrate betwixt the thread. Others ſtrip themſelves of their hairs, and form a maſs of a mixture of ſilk and hairs. Others, after having ſtripped themſelves, plant their long hairs about them, and make of them a ſort of cradle-fence. Others add a greaſy matter, which they procure from their inſide, to the ſilk and hairs; with this they ſtop up the rings of the weft, and it ſerves as a varniſh for them. Others thruſt themſelves into ſand or ſmall gravel, and there conſtruct for themſelves cones of ſand, whoſe grains are connected with the ſilk. Others, laſtly, which have no ſilk, pierce the earth, make a cavity in it like a cone, and ſmear the ſides of it with a kind of glue or paſte.

Another ſpecies, which is far more induſtrious than the former, perform a work which we cannot too much admire. You have lately ſeen deſcribed thoſe cones which reſemble an inverted boat: this is likewiſe the form that this ſpecies give to their cone; but they do not make it entirely of ſilk. They ſtrip off little pieces of bark with their teeth, of a rectangular figure, nearly even and alike, and diſpoſe them with all ſkill and propriety; with theſe they compoſe the principal

principal parts of the cone. Theſe great parts are likewiſe formed of a conſiderable quantity of very ſmall inlaid work, placed end to end, and joined together with ſilk. In a word, we are apt to fancy that we are looking at an inlaid floor, or a piece of inlaid work.

5. The moſt ſolitary of all inſects are ſuch as live in the inſide of fruits. Each fruit lodges only one caterpillar or worm. We are ignorant of the cauſe of this remarkable fact. We only know, that a curious obſerver having attempted to cauſe caterpillars of this ſpecies to live together, they furiouſly engaged each other as often as they met. It is then inconteſtably true, that the diſpoſition of theſe caterpillars is antiſociable. Several have metamorphoſed themſelves in the very fruit that has ſerved them for a retreat and for proviſion; they dig cavities in it, which they line with ſilk, or in which they ſpin their cones. Others, which are the greater part of them, quit the fruit, and metamorphoſe themſelves in the earth.

6. Thoſe inſects that roll up or fold the leaves of a great number of plants are alſo perfect hermits. This proceeding is common to many caterpillars. They thus procure for themſelves little cells, which are convenient lodgings for them, in which they are always ſure to find nouriſhment, for they eat the walls of the cell; but they are always very careful never to touch that part which is deſtined to cover them. The different methods in which theſe caterpillars lodge themſelves, give room for diſtinguiſhing them into tyers, folders, and rollers.

The art of the tyers is in general the moſt ſimple. It conſiſts in joining ſeveral leaves together with ſilk threads, in order to form them into one entire parcel, in the centre of which is the lodge of the little hermit.

The procedure of the folders ſuppoſes more refined operations. They fold the leaves either in the whole, or in part. In the whole, when the portion folded is turned back flat upon another part of the leaf: and in

part,

part, when they only ſimply bend the leaf more or leſs.

But the labour of the rollers is moſt of all to be admired. They live in a kind of roll, whoſe dimenſions, form, and poſition vary in different ſpecies. Some give it a cylindrical figure; others, the form of a cone, which is likewiſe as well-made as thoſe the grocers uſe. The leaf is always rolled ſpirally, or as wafers are. The roll or cone is commonly laid on the leaf; but ſometimes, which is very remarkable, it is fixed on it like a nine-pin.

Does my reader imagine that mechaniſm preſides over the conſtruction of theſe various works? Does he conceive in what manner an inſect, that has no claws, is able to roll up a leaf, and to keep it ſo? We know in general that caterpillars ſpin: and can in ſome meaſure diſcover, it is by the aſſiſtance of their threads that our ſkilful rollers cauſe the leaves to take the form of a cylindrical or conical tube. We ſee in effect parcels of threads diſtributed from one diſtance to another, which hold the roller confined to the leaf. But how can theſe threads, which ſeem only to perform the office of ſmall cables, be capable of rolling up the leaf? This we imagine ourſelves able to gueſs at, but without effect. We ſuppoſe, that by faſtening threads to the edge of the leaf, and drawing theſe threads towards her, the caterpillar forces the edge to riſe and turn itſelf; which is by no means the caſe. The uſe the induſtrious inſect makes of its ſtrength, conſiſts of a more refined mechaniſm. He fixes a number of threads to the border of the leaf, but does not draw it to him. By means of them he bends the other extremity to the ſurface of the leaf. The threads of one and the ſame parcel are nearly parallel, and compoſe a little ribband. By the ſide of this ribband the inſect ſpins a ſecond, which paſſes over and croſſes the former. This then is the ſecret of its mechaniſm. In paſſing over the firſt ribband in order to extend the ſecond, it bears on the firſt with the whole weight of its body; this preſſure, which tends to force down the ribband, obliges the edge of the leaf to which it is faſtened,

tened, to riſe. The ſecond ribband, which is at the ſame time ſtruck on the flat part of the leaf, preſerves on the edge that alteration or bending which the inſect was diſpoſed to give it. If we narrowly examine theſe two ribbands, their effect will be viſible. The ſecond will appear very tight, and the firſt very ſlack; the reaſon is becauſe the latter has no greater degree of action, nor indeed ought to have. You now comprehend that the roll is gradually formed by the repetition of the ſame operations on different parts of the leaf. But it often happens that the coarſer edges reſiſt too much; the inſect knows how to weaken them by gnawing them here and there. In order to form a cone, ſome more performances are neceſſary. The roller cuts with her teeth, on the leaf, the part that is to compoſe it. She does not detach it altogether from it; it would then want a baſe; ſhe only ſeparates that part which is neceſſary to form the foldings of the cone. The part is properly a ſlip, which ſhe rolls as ſhe cuts it. She raiſes the cone on the leaf, almoſt in the ſame manner as we erect an inclined obeliſk. She fixes threads or little cables near the point of the pyramid; ſhe preſſes on them with the weight of her body, and thus forces the point to raiſe itſelf. You may form an idea of the reſt; the mechaniſm is the ſame as that employed in making a roll.

Theſe cells, in which the caterpillar lives, ſerve likewiſe as a retreat for the chryſalis. This latter would not probably be ſufficiently well accommodated with a bare covering of leaf. The caterpillar lines the cell with ſilk tapeſtry. Other ſpecies ſpin a cone for themſelves in it.

7. Some leaves of plants are ſcarcely thicker than paper. Would any one imagine there were inſects ſkilful enough to provide a lodging in ſuch thin leaves as theſe, ſo as to ſhelter themſelves from the injuries of the weather? A leaf is to them a vaſt country, wherein they make roads for themſelves that are more or leſs winding; they mine in the ſubſtance of the leaf, as our miners do in the earth. From hence alſo they have taken the name of miners of leaves. They are extremely

extremely common: ſome belong to the claſs of caterpillars; others to that of worms. They cannot bear to be naked; and it is for the ſake of covering themſelves that they inſinuate themſelves between the two foldings of a leaf. They find their ſubſiſtence there at the ſame time. They eat the pulp of it, and, in eating, trace out a way for themſelves. Some dig there ſtrait or crooked trenches. Theſe are gallery miners. Others mine round about them, in circular or oblong ſpaces, theſe are miners at large. Their teeth are the inſtruments the mine with; but ſome worm-miners dig by means of two hooks reſembling our pick-axes. Several of thoſe inſects ſpin within the mine, the cone wherein they are to transform themſelves. Others quit the mine, and metamorphoſe themſelves elſewhere. Butterflies that proceed from a mining caterpillar, are little miracles of nature. She has laviſhed gold, ſilver, and azure upon them; with other colours that are more or leſs rich; though we regret that ſhe has not performed theſe maſter-pieces in a more extenſive form.

8. But miners have ſomething ſtill more wonderful to offer to us. Beſtow your attention on thoſe vine leaves that are before you. They are pierced with oval holes, which ſeem to be made in them by a gimblet. The mining caterpillars bored theſe holes, by ſtripping two pieces of ſkin from the leaf, with which they make a cone: that cone is there placed perpendicularly on a vine-prop, at a pretty conſiderable diſtance from the leaf that furniſhed the materials. How was it cut, faſhioned, detached, and conveyed? Let us not vainly attempt to gueſs this: let us rather endeavour to ſurpriſe the induſtrious labourer on her working bench. She mines by way of gallery, and conſtructs her cone at the extremity of the gallery. It is compoſed of two pieces of leaf of an oval form, very thin, even, and like each other. The caterpillar prepares theſe places; makes of them a thin texture, by clearing them of the pulp; ſhe models them, lines them with ſilk, cuts them with her teeth as with ſciſſars, joins and unites them. They already have no connec-

tion

tion with the leaf, notwithſtanding which, the cone does not fall: the caterpillar has taken the precaution to ſuſtain it by ſome threads of the ſame ſpecies with its border. When the cone is finiſhed, the caterpillar applies herſelf to diſengage and tranſport it from its place. She has left a ſmall aperture at one end of it. She cauſes her head to come out at this opening, bears it forward, ſeizes a part of the prop with her teeth, and by an effort draws the cone to her. The threads that hold it give way, and the caterpillar carries her little houſe about with her as the ſnail does her ſhell. Behold her walking; her march is a new myſtery. It has been ſaid that all caterpillars have at leaſt ten legs: this is abſolutely without any, and ſhews us what an opinion we ought to entertain of ſuch naturaliſts. Let us lay in her way a finely poliſhed glaſs, placed perpendicularly. She is not in the leaſt retarded by this, but climbs over the glaſs as on a leaf. By what ſecret art is ſhe enabled to cleave to it, for ſhe has neither legs nor claws to grapple it? You have ſeen caterpillars that ſpin little heaps of ſilk which they fix themſelves to. Our miner ſpins the like, at certain diſtances, according to the track ſhe is to paſs over. She ſeizes one of theſe heaps with her teeth, which becomes in part a ſupport for her; ſhe draws the cone to her, and carries it towards the little heap: faſtens it to it; thruſts her head forwards: ſpins a ſecond heap; fixes herſelf to it in the ſame manner as to the firſt; makes an effort to diſcharge the cone, which ſhe effects, drags it towards the new heap, faſtens it likewiſe to it, and this ſecond ſtep being taken unravels to you the ſecret of her ingenious mechaniſm. By this means ſhe leaves on the bodies over which ſhe paſſes little tracks of ſilk, which ſhe ſpins from ſpace to ſpace. When ſhe has arrived at the place ſhe is inclined to fix herſelf at, ſhe here ſtops the cone intended for a habitation, and places it in a vertical ſituation. There afterwards iſſues from it a very pretty butterfly, as richly clothed, and of the ſame genus, as thoſe of other miners.

9. Other inſects live in great galleries of ſilk, which they

they lengthen and widen as they grow. They cover them with groſs matter, and frequently with their excrements. They conſtruct thoſe galleries on the various bodies they feed upon, and which differ according to the ſpecies of the inſect. The name of falſe moths has been given to all ſuch ſpecies as make thoſe encloſures. You are ſenſible, that thoſe of true moths are portable. The moſt remarkable falſe moths are ſuch as ſettle in bee-hives, and deſtroy the combs. They are without defenſive arms, and are only ſecured with a ſoft and delicate ſkin; notwithſtanding which nature has appointed them to live at the expence of a little warlike people that are well armed, and equally well diſpoſed to defend their ſettlements. Our engineers have frequently recourſe to mines and ſaps in the reduction of places. It is indeed abundantly neceſſary that our falſe moths ſhould excel in this kind of attack, and their works prove that they do. They never march but under cover. They ſcoop long trenches in the thick part of the combs, in what direction they think proper, wherein they are always in ſafety from the enemy. The galleries of this kind are lined within with a very cloſe ſilk tiſſue, and covered on the outſide with a thick layer of grains of wax and excrements. Thus the fine works of the laborious bees are deſtroyed in ſilence by an enemy which they are not able to diſcover, and that ſometimes compels them to abandon their hive. The falſe moths have no intention to procure honey: they never penetrate into the cells that contain it. They only eat the wax, and their ſtomach analyſes the matter which the chymiſt cannot diſſolve. When they have attained their full growth, they make a ſilk cone at the end of the gallery, which they never fail to cover with grains of wax.

Other falſe moths eſtabliſh themſelves in our granaries, where they multiply exceſſively. They covet our moſt valuable commodity. They connect ſeveral grains of corn; they ſpin a little tube in the midſt of this heap, where they lodge. By that means they are always within reach of a plentiful ſtock of nouriſh-

ment.

ment. They feed at their pleaſure on the grains of which they have been careful to form their caſe, and which are like a covering to it. When their metamorphoſis approaches, they abandon this caſe; they neſtle in the inner part of a grain, or in the little cavities they dig in the cielings: theſe they line with ſilk, and there transform themſelves into a chryſalis.

10. There are few inſects which claim ſo good a right to our admiration as thoſe that are equally ſkilful with ourſelves in making clothes, and that undoubtedly learned the art before us. Like us, they are brought forth naked; but they no ſooner come into the world, then they ſet about clothing themſelves. They do not all dreſs in the ſame uniform manner, nor do they uſe the ſame materials in their clothing. There is perhaps a greater diverſity with reſpect to this in the modes of different ſpecies of moths, than in thoſe of different people on the earth. The form of their dreſs is very convenient: it correſponds exactly with that of their body. It is a little cylindrical caſe, which opens at both ends. The ſtuff is manufactured by the moth: the ground of it is compoſed by a mixture of ſilk and hair: but this would not be ſoft enough for the inſect, it is therefore lined with pure ſilk. Our woollen furniture and furs ſupply theſe moths with the hair they employ in manufacturing their ſtuffs. They make a careful choice of theſe hairs; cut them with their teeth, and artfully incorporate them in the ſilk tiſſue. They never change their clothes: thoſe they wore in their infancy, they continue to wear when arrived at maturity. They can then lengthen or widen them as they find convenient. They meet with no difficulty in extending them; this they do by only adding new threads and hairs to each end. But the widening them is not ſo eaſy a matter. They proceed herein exactly as we do in the like caſe. They ſlit the caſe at the two oppoſite ſides, and ſkilfully inſert two pieces of the width required. They do not ſlit the caſe from one end to the other: if they did, the ſides would ſtart aſunder, and be expoſed. They only ſlit each ſide about the middle of it. Rea-

ſon itſelf could not exceed this. Their dreſs is always of the colour of the ſtuff from whence it was taken. If therefore a moth, whoſe clothing is blue, paſſes over a red piece of cloth, the widths will be red; ſhe will make herſelf a harlequin's habit, if ſhe paſſes over cloths or ſtuffs of ſeveral colours. They live on the ſame hairs they clothe themſelves with. It is remarkable, that they are able to digeſt them; and it is ſtill more extraordinary that the colours do not ſuffer the leaſt alteration by digeſtion, and that their excrements are always of as fine a tincture as the cloths they feed on. Painters may collate from our moths powders of all colours, and all kinds of ſhades of the ſame colour. They make little journies: thoſe that ſettle in caſes, do not love to walk on long hairs, but cut all they meet with in their way, and are always provided with a ſcythe as they march. They reſt themſelves from time to time, when they fix this caſe with ſmall cords, and thus cauſe it as it were to ride at anchor. They faſten it more firmly, when they are diſpoſed to metamorphoſe themſelves. They cloſe up entirely both ends of it, in order to clothe in it the form of a chryſalis, and afterwards that of the butterfly.

11. Field moths greatly exceed the domeſtic moths in point of induſtry. They take the ſubſtance of their clothing from the leaves of plants; but it becomes neceſſary for them to prepare this matter, and give it that lightneſs and flexibility proper for the garments. Theſe moths are of the ſpecies of miners; and they inſinuate themſelves betwixt the two membranes of a leaf, which are to them what a piece of cloth is to a taylor; with this difference, that the latter has occaſion for a pattern, which the moths can diſpenſe wit. The remove from theſe membranes all the pulpy ſubſtance that adheres to them, which membranes they make thin and poliſh. They afterwards cut in them, thus prepared, two pieces, which are nearly equal, and like each other; they labour to give them the hollowneſs, windings, and proportions which the form of their caſe requires, and this form is often of an exquiſite kind. They connect and unite them with incredible

ſkill,

ſkill, and conclude by lining them with ſilk. They have nothing to do but diſengage the clothing from within the leaf where it was taken and cut, and that requires but a few efforts.

12. Many field and aquatic moths do not prepare the ſtuff for their clothing. Bits of wood, little ſticks, fragments of leaves, pieces of bark, &c. placed on each other like tiles, compoſe the external clothing of the caſe, which conſiſts of pure ſilk. At other times it is covered with gravel, pebble-ſtones, pieces of wood, little bits of reed, and ſmall ſhells either of muſcles or ſnails, and, what is ſcarce credible, the ſnails and muſcles continue to live in theſe ſhells; for, being in a manner chained to the caſe, they are obliged to follow the moth, that carries them wherever it pleaſes. Thus a moth in its clothing does not appear unlike certain pilgrims. Thoſe that are covered with wood, gravel, ſtones, and other unwieldly matters connected together, pretty nearly reſemble a Roman ſoldier in heavy armour. You rightly judge, that ſuch kind of clothes muſt needs be very roughly formed: but ſome of them nevertheleſs look very pretty, in which the arrangement of the materials makes amends for their coarſeneſs. Aquatic moths reap ſome advantage by dreſſing themſelves in ſuch a ſtrange manner. They muſt be always in equilibrio with the water in the midſt of which they live. If their caſe prove too light, they add a little ſtone to it; if too heavy, they faſten ſome bits of reed to it. All theſe moths metamorphoſe themſelves in their caſe; ſome into butterflies, others into flies, and others into beetles.

Some field moths borrow no ſtrange matters to clothe themſelves with; they dreſs entirely in ſilk; but their tiſſue is much cloſer, finer, and more gloſſy, than that of the moſt beautiful caterpillars. It has a ſtill greater ſingularity; being compoſed of little ſcales, like thoſe of fiſhes, partly placed on each other. The caſe has ſometimes for its laſt covering a kind of mantle, which almoſt entirely encloſes it, and is compoſed of two principal pieces, whoſe figure reſembles

that of a bivalve ſhell. Moths that procure the matter for their clothing from their own fund, muſt be able to lengthen and widen it at pleaſure; the expence attending the obtaining of it was too great to admit of their making a new one as often as there ſhould be occaſion. So that they are able to enlarge it in a wonderful manner. They do not add breadths to it as the domeſtic moths do: but ſlit it from one part of it to another, according to its length, and immediately fill up the intervals with new threads, of a length proportioned to the ſpace required. This caſe ſerves them likewiſe as a kind of cone, wherein they transform themſelves into butterflies.

You have taken a ſurvey of the produce of a multitude of different inſects, and are with good reaſon aſtoniſhed at the prodigious variety contained in them, all relative to one and the ſame general end, and all of them likewiſe as much diverſified as thoſe of our artiſans. How does it happen, that amongſt ſo many inſects as prepare themſelves for their metamorphoſis, ſome hang by their hind-part, others faſten themſelves with a girdle, whilſt others make themſelves cones? How came it to paſs, that of thoſe that conſtruct theſe cones, ſome form them of pure ſilk, and others compoſe them of matter of different kinds? Why is the form of theſe cones ſo various in different ſpecies? Wherefore do ſome inſects ſo artfully roll up the leaves of plants, and others only faſten or fold them together? How can we account for the mining of theſe leaves by ſome only, and that the reſt ſhould not all mine them in the ſame manner? In ſhort, how ſhall we aſſign a reaſon why the moths are not all clothed in the ſame dreſs?

All theſe wherefores, and a thouſand others that may be formed on the productions of nature, are ſo many engimas propoſed to beings that are baniſhed into a corner of the univerſe, and whoſe ſight, as ſhort as that of the mole, can only perceive the neareſt objects, and the moſt direct and moſt ſtriking relations.

It behoves us to remain in the place that has been allotted for us, from whence we can only diſcover ſome links of the chain. One day we ſhall diſcover more of them, and ſhall ſee them more diſtinctly. Mean while we may conſider theſe proceedings of inſects, ſo diverſified and replete with induſtry, as an agreeable ſpectacle exhibited by nature to the eyes of the obſerver, that furniſhes him with an inexhauſtible ſource of reflective pleaſure and uſeful inſtruction. He is led to the Author of the univerſe by the thread of the caterpillar, and he admires in the variety of their means, and in their tendency to the ſame end, the fecundity and wiſdom of the Ordaining Mind.

This ſight becomes ſtill more intereſting, when the obſerver undertakes to bewilder inſects, and draw them from their natural track. They then ſhew him reſources, which he had not foreſeen, and that ſurpaſs his expectation. When falſe moths of the wax ſpecies are in want of wax, they can make galleries of leather, parchment, or paper. A caterpillar has been ſeen to conſtruct a cone of little pieces of paper which have been given him, and that have been cut at pleaſure. It has taken hold of them with the teeth and fore-legs, tranſported them to the place where it intended to fix, ranged them there, faſtened them with threads, laid ſome of them edge-wiſe, others flat, forming of the whole, it is true, an aſſemblage that appears a little ſtrange; but anſwering perfectly to a cone. It would have given it a more regular figure, had it worked with materials ſuited to its ſpecies. Ere we had learnt to prepare and dreſs woollens and ſkins of animals, the domeſtic moths were not without clothing. They were then perhaps habited in the ſame manner as the field moths.

14. We do not expect to make any material diſcoveries from ſhell-fiſh that are ſhut up in an almoſt ſtony encloſure; they ſeem very ſtupid; but they are not all ſo ſenſeleſs as they appear to be: we ſhall with pleaſure contemplate the proceedings of ſome of them.

Divers

Divers ſpecies of ſea ſhell-fiſh are furniſhed with two pipes, by means of which they ſuck in the water, and which they take care to keep raiſed above the veſſel they are accuſtomed to ſink into more or leſs. Some ſpurt out the water to the diſtance of ſeveral feet. That particular part which in ſome performs the progreſſive or retrograde motion, very much reſembles a real leg with a foot joined to it; but this leg is a Proteus, which aſſumes all kinds of forms to ſupply the neceſſities of the animal. It does not only make uſe of it to crawl with, ſink into a veſſel, or retire from it; but employs it with much greater ſkill to perform a motion that one would not imagine a ſhell-fiſh capable of. A ſhell-fiſh that leaps, muſt appear very extraordinary. It is a tellina that you are now ſeeing. You may obſerve that ſhe has placed the ſhell on the top or point. She ſtretches out her leg as far as poſſible; ſhe cauſes it to take hold of a conſiderable part of the circumference of the ſhell, and, by a ſudden motion, ſimilar to that of a ſpring that is ſlackened, ſtrikes the ground with her leg, and thus leaps to a certain diſtance.

15. The cutler never creeps: it penetrates perpendicularly into the ſand. It there digs itſelf a ſort of cell, which is ſometimes two feet long, in which it goes up and down at pleaſure. Its ſhell, whoſe form a little reſembles that of the handle of kniſe, has occaſioned it to receive the name of cutler. It is compoſed of two long pieces, hollow like a gutter, and joined together by membranes. The body of the animal is encloſed in a caſe. The part whereby it exerciſes all its motions, is placed in the centre. This is principally deſigned to perform the office of a leg, and acquits itſelf exceeding well. It is fleſhy, cylindrical, and pretty long. The extremity of it, when neceſſary, can roll itſelf up like a ball. View the cutler when extended on the ſand. You behold it working, in order to pierce into it. It thruſts out its leg at the lower end of the ſhell; ſtretches it, and cauſes the extremity of it to aſſume the form of a ſhovel that is ſharp on both ſides, and terminates in a point. It directs it towards

wards the ſand, and applies the edge and point for introducing it farther. After the aperture is made, it extends its leg ſtill more, and cauſes it to penetrate deeper into the ſand; he bends it like a hook, with which taking hold of a ſupport, he draws the ſhell to him, forcing it upright by degrees, and afterwards cauſes it to deſcend into the hole. Is he diſpoſed ſtill to continue ſinking? He thruſts his whole leg out of the ſhell; fixes in the ſand the ball which is then at its extreme part; immediately contracts this leg; his large head, which is ſtrongly fixed in the hole, being leſs inclined to re-aſcend than the ſhell is to go downwards, the cutler deſcends into the ſand, which is his firſt ſtep into it; he has nothing to do but to repeat the ſame operations, in order to advance farther and farther into it. Is he diſpoſed to go up again to the ſurface? He puſhes forth the ball, and at the ſame time makes an effort to extend his leg; the ball, which is averſe to a deſcent, preſſes the ſhell towards the top of the hole. It is pretty remarkable, that the cutler, which lives in ſalt water, dreads the touch of ſalt. If a pinch of it be caſt into his hole, he will come out of it immediately. But if he be caught, and afterwards permitted to re-enter his cell, it will be in vain to throw ſalt into it, ſince he will not quit it on that account. It is ſaid by ſome, that he remembers having been taken; and this is ſo true, that when people do not catch him, he may be made to come out at one's pleaſure, by throwing ſome freſh ſalt into the hole. It ſeems, then, that he is aware of the ſnare that is laid for him, and is unwilling to be taken by it.

16. Caſt your eyes on this ſtone, which I have juſt now taken up from the ſea-ſhore. A ſhell-fiſh fixes his habitation in it. Obſerve, that on the ſurface of the ſtone there is a very little hole; it is by that the ſhell-fiſh has entered, and you may judge of the ſmallneſs of it by that of the aperture. We will break the ſtone aſunder, that we may ſee the animal that dwells in it. How great muſt your ſurpriſe be! You behold a great ſhell-fiſh, near three feet in length, whoſe ſhell is formed of three ſmooth pieces joined together by a ligamentary

gamentary membrane. It is lodged in a great cavity, that is hollow like a funnel. The upper part of the cone is in the little hole you ſee on the ſurface of the ſtone. This ſhell-fiſh is a dail or pholas. How could it be able to pierce ſo hard a ſtone? Or how go through ſo narrow a paſſage? Draw near this clayey ſhell which the wave has juſt left. It is pierced through with a multitude of ſuch holes as you ſee in the ſtone you have in your hand. All theſe holes are inhabited by young dails, which are only a few lines long. They had then no occaſion to penetrate into a hard ſtone. Moiſt clay makes but little reſiſtance. But the ſea inſenſibly converted this clay into ſtone: the dail, which at firſt found himſelf lodged in a ſoft earth, afterwards perceived that he was within a ſtone cell. We have ſeen that the cutler can come out of his hole when he pleaſes: the dail never quits his; nor indeed can he; ſince the form of this kind of cell will not admit of it. All that he can do is, to ſtretch out two pipes at the opening of the hole, with which he receives and rejects the water. The cutler does the ſame. You are impatient to be informed of the inſtrument with which the dail hollows his cell. This inſtrument has no edge to it: it is purely fleſhy, and ſhaped like a lozenge.

17. We will quit ſhell-fiſh for a time. Divers animals of the ſea will likewiſe entertain us with the wonders of their Author. Let us beſtow on them the attention they deſerve: what we are about to relate concerning them, will be found well deſerving notice in natural theology.

On the rocks near the ſea-ſhore you may perceive little fleſhy maſſes, of the ſize of an orange, whoſe form is like that of a counter-bag, and pretty nearly reſembling that of a cone when cut. All theſe maſſes ſeem immoveable, and connected with the rock by their baſe. Some of them are rough, others ſmooth. We have juſt now compared them to a bag or purſe, in which counters are put; but this bag is not folded together, and is likewiſe without ſtrings. They are

nettles

nettles that you ſee; a very ſingular kind of animals, that demand a cloſer attention. The body of the animal is in effect encloſed within a ſort of fleſhy purſe, of a conic figure. At the top of the cone is an opening, which the nettle increaſes or contracts at pleaſure.

Let us conſider the ſea-nettles that we have now before us: there is one that opens and unfolds itſelf like a flower: it has put forth a hundred and fifty fleſhy horns, like thoſe of ſnails, diſtributed in three rows round the aperture. You remark, that little water-ſpouts iſſue from theſe horns; conſequently they do not perform the ſame functions as thoſe of ſnails; they are analogous to the pipes of dails, cutlers, and other ſhell-fiſh which you have ſeen. You alſo remark, that the form of theſe nettles varies greatly, that their baſe is ſometimes circular and ſometimes oval, and that the height of the cone varies according to the dimenſions of its baſe. It riſes or falls as the baſe grows narrower or wider. Touch one of theſe blown nettles: ſee with what quickneſs it cloſes and contracts itſelf. But you perceive no progreſſive motion: are the nettles then condemned to paſs their whole life fixed to the ſame ſpot? The ancients thought ſo. What are we to think of them? About an hour ago, this large nettle, which you ſee on your right hand, touched this point of the rock: obſerve that it is now above an inch diſtant from it. You are ſurpriſed that you did not perceive it walk, for you looked at it more than once; the reaſon of this is, becauſe its progreſſive motion is as ſlow as that of the hand of a clock. We may be curious to know how the nettle performs it. All its body is externally furniſhed with various orders of muſcles. Thoſe of the baſe go, like rays, from the centre to the circumference; others deſcend from the top towards the baſe. Theſe muſcles are alſo canals, full of liquor, which iſſues out on pricking them. They are emptied and filled at the pleaſure of the nettle. By the exerciſe of theſe muſcles or canals, the progreſſive motion is performed. Let us follow the nettle when ſhe is diſpoſed to go forwards. Her baſe is circular. She

ſwells the muſcles that are on that ſide whither ſhe is tending. She injects her liquor into them, which, by inflating, lengthens them, They cannot extend themſelves unleſs the edge correſponding with the baſe ſhifts its place, and advances a little way. At the ſame time ſhe looſens the oppoſite muſcles, and empties their canals. They contract. This they cannot do, except the edge of their correſponding baſe goes in a little, and exactly in the ſame degree as the oppoſite one projects. Such is the mechaniſm whereby the firſt ſtep of our nettle is performed. In order to make a ſecond, ſhe cauſes the baſe again to receive a circular form, by puffing up equally all the canals: ſhe afterwards repeats the ſame operations we have juſt taken a view of.

The whole progreſſive motion of nettles is not confined to this. They have another method of walking, which more nearly reſembles that of inſects. They are able to make uſe of their horns like legs. But theſe horns are on the upper part of their body: the nettle is fixed by its baſe againſt the rock: how do theſe horns perform the office of legs? The nettle you are following will ſhew you the method. She turns herſelf upſide down; the baſe abandons the rock, and the cone is placed on its top. All the horns ſhoot forth, and you ſee them fix themſelves to the rock. They are gluey and rough to the touch: for which reaſon they meet with no difficulty in faſtening to it.

18. Would you believe that an animal which is entirely of a fleſhy nature, and is provided with no inſtrument to open or pierce the ſhells, feeds upon ſhell-fiſh? Nettles that are but of a middling ſize ſwallow great ſhell-fiſh, and it is difficult to conceive how they are capable of being lodged within the nettle. It is true, the latter being entirely fleſhy is ſuſceptible of a great diſtenſion. It is a ſort of ſupple purſe, that may be ſtretched occaſionally. The opening of the purſe is properly the mouth of the nettle. Its inſide not being tranſparent, one cannot ſee what paſſes therein, or by what means the nettle voids the ſhell-

fiſh.

fiſh. The moment ſhe has ſwallowed it, ſhe cloſes herſelf. Look at this young nettle that is ſhut up quite cloſe: ſhe has juſt ſwallowed a pretty large ſnail, and is buſy in digeſting it. She is now opening herſelf again, and diſcharging the empty ſhell. On the ſide of her is another nettle which beſpeaks your attention: ſhe has ſwallowed a great muſcle, and is making ineffectual efforts to void the ſhell. She is not able to effect it: the ſhell preſents itſelf in an unfavourable poſition at the aperture, and you begin to be in pain for the unhappy nettle. She has a reſource that you did not imagine. Caſt your eyes towards the baſe; the ſhell is evacuated through a large wound; the nettle is delivered from it by that means, and is no more affected by the great gaſh made thereby, than we are by a ſcratch.

19. All nettles do not procure a diſcharge by ſo violent a method: they have another, which they commonly uſe with ſucceſs. They turn themſelves inſide out like a glove or ſtocking, ſo that the edges of the opening, which reſemble lips, fold themſelves on the baſe. The mouth is then of a prodigious width, and the bottom of the purſe almoſt uncovered.

Nettles do not thus ſhift themſelves merely to get rid of heterogeneous bodies; they put themſelves into the ſame poſture when they bring forth. They are viviparous. The young are produced completely formed; and we ſee nettles in miniature appear. The aperture through which they paſs, is ſo wide as to admit a multitude of them at the ſame time. Notwithſtanding which, they always come forth ſingly. They are at firſt encloſed in certain folds concealed at the bottom of the purſe.

Do nettles reſemble polypuſes by the ſingular property of being multiplied and grafted by ſlips? Experiments have put this beyond all doubt. Of a ſingle nettle, divided according to its length or width, are made two or three, which at the end of a few weeks are perfect and complete. They may likewiſe

be

be grafted; but it will be neceſſary to have recourſe to ſeaming. You are now no longer ſurpriſed at the conſolidation of that enormous wound made at the baſe of a nettle that iſſues out thereat. A wound of this nature is nothing, when compared to that which another animal ſuſtains when cut in pieces, without ceaſing to live and multiply in each piece. Nettles may then be called a ſpecies of polypuſes with arms of a monſtrous ſize; or, if you prefer the expreſſion, polypuſes with arms are a ſpecies of very minute nettles.

Let us quit theſe rocks that ſwarm with nettles, and betake ourſelves to that little creek where the ſea is very calm. Stoop a little, and obſerve the ſurface of the water. What do you perceive? A kind of greeniſh jelly floating upon it. Its form is like that of a broad muſhroom. It is near two feet in diameter. Take a piece of it betwixt your fingers; handle it for a few minutes: you will ſee it diſſolve into water. The heat of your hand was ſufficient to melt it. Does it enter into your thoughts that this jelly is a real animal, and even a ſpecies of nettle? It has been called wandering nettle, becauſe it never fixes, and floats from one ſide to the other. Its convex ſurface preſents us only with an infinite number of little grains or nipples. But its inferior ſurface, which is concave, is extremely organized: in that we may ſee a great number of canals, which are regularly diſpoſed, and made with great art, ſome being circular, and others diſpoſed regularly, like the felloes of a wheel, and which are full of a watery liquor, which paſſes from one to the other.

This ſtrange animal wanders about in the ſea. It is ſpecifically much heavier than water. He cannot therein ſuſtain himſelf, without the aſſiſtance of a ſpontaneous motion, which is worth obſerving, and cannot be ſeen but in places where the water is calm. It is ſo in this little creek on the extremity of which we are ſitting. Look with attention on the ſurface of that jelly which offers itſelf to your view. Obſerve that it has certain motions, which you are tempted to compare

compare with thoſe of the ſyſtole and diaſtole. However, they are not the ſame. Their only end is to cauſe the nettle to float. You ſee that in the ſyſtole kind, the ſurface of the animal becomes very convex, and that in the diaſtole it becomes ſuddenly flat and wide. Such is our glutinous nettle's method of floating. When dried in the ſun, it is reduced almoſt to nothing. We imagine that we ſee a little piece of parchment or very tranſparent paſte. There is no room to doubt that this ſpecies of nettle multiplies, like the reſt, by ſlips; but I do not know that there has been any experiment made concerning this. A jelly muſt be attended with greater eaſe in regenerating itſelf than organized bodies of the ſame genus, that are of a more firm and cloſe conſiſtence.

20. There are no regular or ſtrange forms of which the animal kingdom does not afford us models. Here is an animal whoſe form is preciſely that by which we paint the ſtars in the firmament. It is nearly flat. From the middle of its body proceed four or five rays, which are almoſt equal, and reſembling each other. Its upper ſurface is covered with a hard, callous, and very rough ſkin. In the centre of the inferior ſurface is placed the mouth, which is provided with a ſucker, that the ſtar makes uſe of to imbibe the ſubſtance of the ſhell-fiſh ſhe feeds upon. Five ſmall teeth or pincers hold it confined whilſt ſhe ſucks them, and perhaps aſſiſt in the opening his ſhell. The legs of the ſtar are a real curioſity. They are joined to her inferior ſurface, and diſtributed with ſymmetry in four rows, each conſiſting of ſeventy-ſix feet; ſo that each ray is furniſhed with three hundred and four feet, and the whole ſtar with fifteen hundred and twenty. Yet with ſuch a number of feet, the ſtar goes but little faſter than the muſcle, which has only one. Theſe legs perfectly reſemble the horns of the ſnail, both by their figure, conſiſtence, and exerciſe. When the ſtar is diſpoſed to walk, ſhe ſpreads her legs as the ſnail does her horns, and with the extremity of them ſeizes the various marine bodies on which ſhe crawls. She commonly puts forth only one part of her legs; the remainder are

kept

kept in reſerve againſt thoſe neceſſities which may happen. The mechaniſm which preſides over their motions is an illuſtrious proof of a Creative Mind. Let us open one of the rays by ſlitting it lengthwiſe, and we ſhall diſplay the principal ſprings of the machine. An almoſt cartilaginous partition, made in the form of vertebræ, divides the whole ray. In every part of this partition you perceive two rows of little balls, like pearls of the fineſt water. The number of theſe little balls is preciſely equal to that of the legs. Thus you ſee that each ball anſwers to a leg. You can diſtinguiſh a limpid liquor in theſe balls; preſs your finger upon them; they empty themſelves; the liquor paſſes into the correſponding legs, and they immediately extend themſelves. The ſtar then need only preſs the balls in order to ſpread the legs. But they are capable of contraction, and when they contract themſelves, they force the liquor back again into the balls, from whence it may be driven afreſh into the legs, to procure a progreſſive motion.

You conjecture, that theſe eggs, which reſemble theſe tubes through which divers kinds of ſhell-fiſh reſpire, ſerve likewiſe for the ſame uſes. But nature who has been ſo laviſh in providing the ſtar with legs, has been alſo liberal in beſtowing on it the organs of reſpiration. She has even multiplied them in a greater degree. They are very ſmall conic tubes, diſpoſed in knots, and produce an equal number of little water ſpouts.

Amongſt our ſtars, you obſerve there are ſome which have only two or three rays, and by looking more narrowly at them, you diſcover ſeveral very minute rays, juſt beginning to ſhoot out. Are then animals, that are formed by a repetition of ſuch a great number of parts, both outward and inward, regenerated like polypuſes, whoſe ſtructure appears ſo ſimple? Nothing is more true, and the ſtars you are now looking at, will afford you proof of it. Theſe animals often chance to loſe two or three of their rays, and they are no more affected by this loſs than polypuſes are by parting with ſome of their arms. We may mangle ſtars or cut them in pieces, but cannot deſtroy them by

that

that method. They will recover from their ruins, and each piece becomes a new ſtar.

21. Sea-hedgehogs, like the land ones, derive their names from their prickles. But thoſe of the former are quite different from ſuch as belong to the latter.

The form of theſe hedgehogs is that of a round button. It is hollow within, and its ſurface is elaborately wrought. We might compare the workmanſhip of them to that of certain copper or wire buttons. A multitude of tubercles, like little triangles divide the whole ſurface of the button. Theſe triangles are ſeparated by ſtripes, which are regularly ſpaced, pierced with holes, and diſtributed with great ſymmetry in ſeveral lines. Theſe holes paſs through from one part to another, the whole thickneſs of the ſkeleton, for the body of our hedgehogs is a kind of bone-box. Each hole is a ſocket, wherein is a fleſhy horn, like thoſe of a ſnail, and ſuſceptible of the ſame motions. There are therefore as many horns as holes, and there are reckoned to be at leaſt three hundred. The hedgehog, like the ſnail, makes uſe of her horns for feeling the earth, and the various bodies it meets with in its paſſage. But it particularly employs them to faſten with and caſt anchor. The tubercles are the baſes of many prickles or legs, and their number amounts to at leaſt two thouſand one hundred. So that there is hardly any part of the body of a hedgehog that is deſtitute of a leg. It can for that reaſon walk as well on the back as on the belly; and in general, let it be in what poſture it will, it has always a great number of legs ready to carry it, and horns to fix it with. The legs it uſes with the greateſt eaſe are thoſe which ſurround the mouth; but when it pleaſes, can walk by turning round on itſelf like a wheel. On the back or the top of the button, is another aperture which is thought to be the anus. This then is an animal that is provided with at leaſt thirteen hundred horns, and two thouſand one hundred legs. What a great number of muſcles muſt it require to move ſo many horns and legs? How many fibres muſt there be in each of theſe muſcles? What an aſtoniſhing multiplication of parts in this little animal?

mal? What regularity, what ſymmetry, and even harmony in their diſtribution! What variety in their exerciſe!

When the hedgehog would advance, he draws himſelf forwards with thoſe legs that are neareſt the place he would go to, and puſhes himſelf towards it with the oppoſite ones. All the reſt remain at that time in a ſtate of inaction. At the ſame time that one part of his legs are at work, the horns that are neareſt to them exert themſelves to ſound the way, or find anchorage for the animal.

22. Moſt ſhell-fiſh are produced with their clothing. The ſhell they bear grows with them and by them. But Bernard the hermit, a kind of cray-fiſh ſo called, comes into the world without a ſhell, though he has need of one in order to cover the greater part of his body; whoſe thin and delicate ſkin would ſuffer too much from being naked. Has nature then behaved to it as a ſtep-mother, by denying it ſo neceſſary a garment? By no means: as ſhe is beneficent towards every other animal, ſo has this likewiſe been the object of her attention. It is true, ſhe has not provided it with a ſhell; but has made it amends by enabling it to clothe itſelf with one. Taught by ſo great a miſtreſs, our hermit has the ſagacity to take up his lodging in the firſt empty ſhell he meets with. He applies himſelf indifferently to all that are of a ſpiral conſtruction. He often retires ſo far into them, as not to be perceived, whereby the ſhell appears empty. If the ſhell ſhould prove too narrow, he quits it, in order to ſeek for another, more ſuitable to his bulk. It is ſaid, there ſometimes happen conteſts between our hermits about a ſhell, and that victory is decided in favour of him who has the ſtrongeſt claws. Our battles have ſcarcely ever a cauſe of equal importance for their object.

23. You have been already aſtoniſhed at the ſkill diſplayed in the progeſſive motion of ſeveral ſhell-fiſh, your amazement will be redoubled when you learn that ſome of them can ſpin: and you are impatient to

ſee

ſee them at work. Let us walk on the ſea ſhore. You there diſcover a number of muſcles, ſome by themſelves, and others joined in companies. Conſider them more attentively you will obſerve that ſome of them are faſtened to ſtones or to each other, by a great number of ſmall ſlender ſtrings. Let us ſelect one of theſe muſcles, that we may obſerve it the more cloſely; the better to diſcover their operations. Here is one of them endeavouring to fix itſelf to this ſtone that is near the ſurface of the water. The ſhell is partly open; it has truſt out from it a kind of ſupple tongue, which it lengthens and contracts alternately. Remark that it often applies the ends of it to the ſtone, and immediately draws it back again into the ſhell, that it may again put it forth the next moment. From the root of this kind of tongue there iſſue certain threads, which are equal in ſize to a hog's briſtle. Theſe threads part from each other as they come out, and their extremity ſticks to the ſtone. Theſe are ſo many ſmall cables which hold our muſcle at anchor. There are frequently a hundred and fifty of theſe little cables employed in mooring a muſcle. Each cable is ſcarcely two inches long.

The muſcle herſelf has ſpun all theſe cords. The tongue not only ſerves them as it does other ſhell-fiſh, for arms, to faſten themſelves with, and for legs to creep with; but is alſo the ſpinning inſtrument which produces thoſe numerous threads, by means of which the muſcle reſiſts the impulſe of the waves. From the root of the tongue to its extremity there is a groove, which divides it according to its length into two equal parts. This groove is a real channel, furniſhed with a great number of ſmall muſcles that open and ſhut it. In this channel is contained a viſcous liquor, which is the matter of the threads emitted by the muſcle. At its firſt appearance this channel is exactly cylindrical, and is, properly ſpeaking, the place where the threads are moulded. The various motions the tongue of the muſcle we are obſerving gave itſelf a minute ago, all tended to fix it to the ſtone. Thoſe threads which are the whiteſt and moſt tranſparent are ſuch as are newly ſpun. She has not yet finiſhed anchoring herſelf, where-

ſore

fore you perceive her tongue is again extending about two inches, and the tip of it drawing towards the ſtone. The viſcous liquor runs in the channel, and arrives at the extremity of it. This liquor is now conſolidated, and becomes a cylindrical thread. The muſcle ſticks the end of his thread to the ſtone; but is deſirous of applying it by a wider ſurface, in order to render it more adherent For that purpoſe, ſhe adds to it with the tip of her tongue, that little paſte which you obſerved. Her buſineſs now is to extend another cable to ſome diſtance from the laſt. The tongue therefore muſt quit this latter, in order to work elſewhere. How will ſhe be able to effect this? The channel opens itſelf to its utmoſt length, and diſcharges the thread. The tongue being diſengaged from his thread, quickly draws itſelf together, re-enters the ſhell, and the next moment again iſſues from it, to fix a new cable a little farther off.

Did you take notice of a mark of ſkill expreſſed by our muſcle? She has juſt now ſpread the firſt thread; to aſſure herſelf of the goodneſs of it, ſhe immediately puts it to the proof; drawing it ſtrongly towards her, as though ſhe would break it. It has reſiſted this effort, and, ſatisfied with the experiment, ſhe has proceeded to ſtretch out the ſecond thread, which ſhe has tried like the firſt.

Theſe cords which the ſea muſcles ſpin with ſo much art, are in reality as ſerviceable to them as cables are to a ſhip. You aſk me, whether they can weigh anchor? Divers experiments prove they are not endued with that ingenuity. It was not neceſſary for them. But they ſometimes drive with their anchors; it therefore behoves them to have freſh cables in reſerve.

Thus the ſea has its ſpinners as well as the earth: Muſcles are at ſea the ſame that caterpillars are on land. There is nevertheleſs a remarkable difference between them. The work of caterpillars anſwers exactly to that of gold wire-drawers. The ſilk thread is moulded by paſſing through the mouth of the ſpinner, and the caterpillar gives it what length ſhe pleaſes,

which

which in certain cones conſiſts of ſeveral hundred feet. The labour of muſcles may rather be compared to that of work-men who caſt metals. The ſpinning inſtrument of theſe ſhell-fiſh is a real mould which does not only determine the thickneſs of the thread, but alſo its length, which is always equal to that of the ſpinning inſtrument or tongue.

The pinnæ marinæ, which are ſpecies of very large muſcles, are more dexterous ſpinners ſtill. Their threads which are at leaſt ſeven or eight inches long, are extremely fine, and curious works are made with them. If muſcles are caterpillars of the ſea, pinnæ are its ſpiders. The threads of the pinnæ ſerve, like thoſe of muſcles, to moor them with, and defend them from the agitation of the waves. They are prodigiouſly numerous, and being united, form a kind of tuft or ſkain, weighing about three ounces. The inſtrument that prepares and moulds them, reſembles, in the eſſential properties of it, that of other ſhell-fiſh of this kind: except that it is much larger, and the groove that divides it lengthwiſe is much narrower. At the root of it there is a membraneous bag, compoſed of ſeveral fleſhy layers, that ſeparate the ſilk layers from whence the tuft reſults.

24. If all kinds of ſhell-fiſh and ſea-animals have not been enabled to moor themſelves with as much ſkill as muſcles and pinnæ, nature has made them amends for that by affording them means that are no leſs efficacious. Before we quit this ſhore, let us ſtop a little while and examine this ſmall ſhell-fiſh which you ſee faſtened to this rock. It is a goat's eye, or a limpet. Its ſhell, which conſiſts of one piece only, is made like a conic chapiter, under which the whole body is ſheltered, as under a roof. The animal can raiſe or lower this covering as it pleaſes. When it lowers it, the body is entirely concealed, and it reſts immediately on the ſtone. A large muſcle that occupies the whole extent of the ſhell, and that is, as it were, the baſe of it, faſtens the animal to this ſtone. Try to diſengage it from it: you are not able to effect it. It is nevertheleſs

leſs only fixed to the ſtone by a baſe of an inch and a half in diameter. Let us hoiſt a cord round the ſhell; and ſuſpend a weight of twenty-eight or thirty pounds to this cord, the ſhell-fiſh will not quit his hold till after ſome ſeconds, and you are ſurpriſed that ſo ſmall an animal ſhould be endued with ſo great a power of adheſion. You are curious to know from whence he derives this: you examine the ſtone, and it appears to you to be finely poliſhed, whereupon your aſtoniſhment is redoubled. Can it be that the muſcle is able to inſinuate itſelf into the inſenſible parts of the ſtone? Divide the animal tranſverſely; it ſtill adheres as ſtrongly as before. Does it cleave to the ſtone as two pieces of poliſhed marble cleave to each other? But pieces of marble eaſily ſlip each other; and you cannot cauſe ſhell-fiſh ſo to do. This then is the ſecret cauſe of that adheſion which aſtoniſhes you. The muſcle is furniſhed with a viſcous humour, which agglutinates it to the ſurface of the ſtone, and which is ſenſibly felt by touching it with the finger.

But the goat's eye has not been condemned to remain its whole life affixed to the ſame place. It is neceſſary for it to go in ſearch of its food. There is one now creeping on the rock: its great muſcles ſerves him inſtead of legs, and performs the ſame functions as that you have been made acquainted with in the ſnail. The goat's eye then can diſengage himſelf when he pleaſes. It is able to break thoſe ſtrings which are with difficulty disjoined by a weight of eight and twenty pounds. Moiſten your finger, and ſtroke the muſcle with it; the natural glutinous ſubſtance, with which it is endued, can no longer retain its hold. This glue is diſſoluble by water. The whole ſurface of the muſcle abounds with little ſeeds, filled with a diſſolvent liqour. When the animal is diſpoſed to ſhift his quarters, he need only preſs his numerous glands, the diſſolvent iſſues from them and the cords are broken.

The goat's eye has but one certain proviſion of gluey matter. If it be looſened from its place ſeveral times together, its ſtock will be exhauſted, and it will not fix any more.

This

This method of mooring is common to divers ſea-animals. It is particularly ſo to nettles. Its whole ſkin is one entire maſs of glue, which diſſolves very ſpeedily in aqua vitæ. It is with this abundant glue that theſe extraordinary animals faſten themſelves to the rocks.

Star-fiſhes alſo fix themſelves by the ſame method. A viſcous matter is conducted to the extremity of the horns that ſerve them inſtead of legs. Theſe legs become ſtrong ties to them by means of the glue that exſudes from them, and when they are once faſtened, it is eaſier to break than ſeparate them. The norns of hedgehogs are exactly of the ſame nature.

All theſe adheſions are voluntary, and depend ſolely on the good pleaſure of the animal. He joins or diſjoins himſelf as circumſtances require. But there are other adheſions, which are altogether involuntary. Sea-worms that are called pipe-worms, are encloſed in a round tube of a ſubſtance reſembling that of ſhells, and faſtened to ſtones or hard ſand, or even to other ſhell-fiſh. This tube follows the turnings of the ſurface to which it is fixed. The worm never quits this ſhell which he lengthens or widens as he grows. They recal to your remembrance the falſe moths: this may be termed, a falſe moth of the ſea. It emits from its whole body a ſtony juice, which is the matter whereof the tube is formed.

Other worms of this ſpecies, whoſe juice is not of a ſtony nature, but glutinous, make uſe of it for collecting round them grains of ſand, or bits of ſhells, and this ſhell of inlaid pieces is notwithſtanding wrought in pretty exact proportion.

Oyſters, and many other ſhell-fiſh, adhere by a ſtony liquor to the bodies whereon they reſt, and are often by this means cemented to one another. Of ſuch a ſpecies is that univerſal cement which nature makes uſe of, as often as ſhe would erect in the ſea, or eſtabliſh therein a ſhell-work againſt the violent motion of the waves.

We

We have acquired but little knowledge of the induſtry of fiſhes. They are not ſufficiently within our reach. The greateſt part of them inhabit gulfs that are inacceſſible to our reſearches. We do not preſume to think, that all their intelligence is confined ſolely to the devouring of each other. Their migrations are alſo as remarkable as thoſe of birds. They may have need of a kind of genius to enable them to chaſe their prey with ſucceſs, and elude the purſuit of their enemies. The cuttle-fiſh ſcatters about, at a proper ſeaſon, a black liquor, which troubles the water, and hides her from the ſight of ſuch fiſh as attempt to take away her life. Perhaps this liquor may be ſerviceable to her in ſeizing with the greater eaſe thoſe ſhe feeds upon. Other fiſhes can with abundance of art penetrate into very hard ſhells, and extract from thence the fleſhy ſubſtance contained in them. We are not yet acquainted with the uſe the ſword-fiſh, the ſaw-fiſh, and the narval or unicorn-fiſh, make of thoſe enormous inſtruments they wear at the end of their ſnouts; but they are undoubtedly able to handle them. Has not the cramp-fiſh, which ſo ſuddenly benumbs the hand that touches it, a very remarkable method of providing for its ſafety, and an excellent art to propoſe to the meditation of the natural philoſopher? The flying-fiſh, when purſued by others, darts out of the watery element to take refuge in the air, where it is for a time ſuſtained by its great fins.

It is well known that carp are capable of being tamed, and that they will haſten, like fowls, at a certain ſignal, to receive food from the hands of their provider.

It is probable that fiſhes are of all other animals endued with the longeſt lives. We have ſeen carp of an hundred and fifty years old. Fiſhes tranſpire and harden but little: they have, properly ſpeaking, no bones. But they live in a ſtate of perpetual warfare. They all devour, or are devoured by others. Thoſe who attain to their age, muſt acquire an extenſive knowledge of things relating to the ſea. Such Neſtors

as

as theſe may be able to procure us ſome good memoirs of the ſecret hiſtory of a people ſo little known.

25. We conjecture that the emigrations of birds depends principally on the winds. An exact naturaliſt at Malta has aſſured himſelf of this: that the ſame ſpecies always change their climate with particular winds. In April the ſouth-weſt wind brings into that iſland a ſpecies of plovers, and the north-weſt, cardinals and quails. Nearly at the ſame time, falcons, buzzards and other birds of prey come with the north-weſt wind, without ſtopping, and depart in October with the ſouth and weſt. In ſummer, the eaſterly wind conducts the ſnipes to Malta, and, towards the autumn, the north and north-weſt bring thither numerous ſquadrons of woodcocks. Theſe birds cannot fly, like the quails, before the wind; ſince the north wind, which might carry them into Barbary, obliges them to remain in the iſles. Quails, on the contrary, emigrate before the wind from one country to another. The ſouth-eaſt enables them to paſs, in the month of March, from Barbary into France. They return from France in September, and go to Malta by a ſouth-eaſt. The winds, therefore, are the ſignals employed by nature for reminding divers kinds of birds of the time of their departure. In obedience to this voice, they ſet out, and follow the direction it points out to them.

What a ſeries of intereſting circumſtances would not the conſtruction of their neſts alſo preſent us with! A chaffinch or gold-finch's neſt would take us up whole hours in contemplating it. We ſhould inquire where the gold-finch could furniſh itſelf with a cotton ſo fine, ſilky, and ſoft, as lines the inſide of its pretty neſt? After many reſearches, we ſhould find, that by covering the ſeeds of certain willows with a very fine cotton, nature has prepared for the gold-finch the down ſhe employs. We ſhould never be weary of conſidering that kind of embroidery with which the chaffinch ſo agreeably adorns the outſide of his neſt, and on viewing it more narrowly, we ſhould perceive that it is owing to an infinity of little liverworts, artfully interwoven

woven together, and applied with the utmoſt propriety over the whole ſurface of the neſt. The colour of theſe liverworts, which is moſt commonly that of the bark of the tree on which the neſt is ſituate, would indicate that the chaffinch ſeems to intend her neſt ſhould be confounded with the branch that bears it.

26. Shall we viſit the retreats of rats, field mice, badgers, foxes, otters, bears. We ſhould undertake thereby too tedious a journey. Let us limit ourſelves to the rabbit and monkey, as the moſt curious after thoſe of the beaver.

The rabbit and hare, which bear ſo near a reſemblance to each other both in their exterior and interior part, teach us not to truſt to appearances. They eaſily couple together, and produce nothing. They are therefore diſtinct ſpecies.

Moreover, the feeble hare contents herſelf with the lodging ſhe makes for herſelf on the ſurface of the earth. The more induſtrious rabbit penetrates into the earth, and there procures an aſſured aſylum. The male and female live together in this peaceable retreat, fearleſs of the fox or bird of prey. Unknown to the reſt of the world, they ſpend their days in happineſs and tranquillity.

The hare might alſo dig the earth, but does not, neither does the domeſtic rabbit ſince he has no occaſion; his dwelling place being provided for him, he behaves as if he was ſenſible of it. The warren-rabbit ſeems to know that he is unprovided, and procures for himſelf a lodging. But to perceive the relations thoſe retreats have to their preſervation, and to judge that they will ſhelter them from all the inconveniences they labour under, is an operation of the ſoul that borders on reflection, if it be not reflection itſelf.

When the hare is ready to kindle, ſhe digs for herſelf a burrow. This is a winding trench, or one made in zig-zag. At the bottom of this trench ſhe works a great cavity, lining it with her own hairs. That is the ſoft bed ſhe prepares for her young. She does not quit them during ſeveral of the firſt days; and only goes

out

out afterwards to procure nouriſhment. The father at that time knows nothing of his family: he does not dare to enter the burrow. When the mother goes into the fields, ſhe often takes even the precaution to ſtop up the entrance of the burrow with earth ſteeped in her urine. When they are grown ſomewhat larger, the leverets begin to brouſe the tender graſs. The father at that time acquires a knowledge of them, takes them up in his paws, licks their eyes, poliſhes their hair, and diſtributes his careſſes and cares equally amongſt them all.

Obſervations prove that paternity is greatly reſpected amongſt hares. The grandſire continues to be the chief of the whole numerous family, and ſeems to govern it like a patriarch.

27. The tricks of the monkey are known to every body. No one is ignorant with what facility ſhe is tamed, and taught to dance and ſhew poſtures on a ſtaff. Her ingenious proceedings on the tops of the Alps, where ſhe fixes her abode, in the midſt of ſnow and froſt, are not ſo generally known.

Towards the month of October, ſhe enters into winter quarters, and ſhuts herſelf up for the remainder of the ſeaſon. Her retreat is worthy of obſervation. On the brow of a mountain, the induſtrious monkey eſtabliſhes her dwelling. It is a great gallery dug under ground, and made like a Y. Theſe two branches, which have each of them an opening, terminate at a corner. Such is the apartment of the monkey. One of the branches deſcends below the apartment, according to the ſloping of the mountain; it is a kind of aqueduct that receives and carries off the excrements and filth. The other branch, which riſes above the habitation, ſerves for an avenue and place to go out at. The apartment is the only part of the gallery which is horizontal. It is lined with a thick layer of moſs and hay. It is certain that monkeys are ſociable animals, and that they work in common on their lodging. They amaſs, during the ſummer, ample ſupplies of moſs and hay. Some mow the graſs, others gather it, and

by turns they ſupply the office of a cart to convey it to the ſtorehouſe. One of the monkeys lies on his back, opens his paws to ſerve inſtead of racks, ſuffers himſelf to be loaded with hay, and drawn by the reſt, who hold him by the tail, and are careful to prevent the carriage being overturned on the road. Their feet are armed with claws, which enable them with great eaſe to dig into the earth. As ſoon as they have made a hollow place in it, they throw behind them the dirt they extract from the mine. They paſs the greateſt part of their life in their habitation; they retire into it during the rain, or on the approach of a ſtorm, or at the ſight of ſome imminent danger. They ſeldom quit it except in fine weather, and go but a little way from it. Whilſt ſome are ſporting on the turf, others are buſy in cutting it, and a third party are acting as ſcouts on the eminences, to give notice to the foragers, by a whiſtle, of the enemy's approach.

During the winter, monkeys eat nothing. The cold benumbs them, ſuſpends or greatly diminiſhes perſpiration, and other excretions. The fat with which their belly is well provided paſſes into the blood, and reſtores it. We might affirm that they foreſee their lethargy, and are apprized that they ſhall then have no need of nouriſhment; for they do not think of hoarding up proviſions, as they do materials for furniſhing their lodging.

28. We have greatly admired the ingenious and almoſt intelligent mechaniſm, by which divers caterpillars roll up the leaves of trees. You ſee theſe aſh-leaves that are rolled up like a coffin. They are inhabited by a little caterpillar, that has formed for itſelf therein a cone of pure ſilk, nearly reſembling a grain of corn. We cannot examine this cone without opening the coffin. Let us do it with caution. The cone is lodged in the centre. You perceive little gutters on the exterior part of it. Obſerve particularly in what manner this little cone is ſuſpended in the middle of the coffin, by the help of a thread, one of whoſe extremities is fixed to the top of the cone, and the other to its baſe, or the flat part of the leaf. Look narrowly at the

the place where the thread joins to the flat part of the leaf: you will perceive a ſmall piece in it exactly circular, bored in the thick part of the leaf, and that ſeems to conceal ſome ſecret deſign. This you will find in many coffins; but it often happens that you will ſee in that place a little round hole, well turned, that appears to have been made by a gimblet. The circular piece is the work of the caterpillar: it has ſkilfully gnawed that part of the leaf; and has cut a little piece of it in a circular form, which it has been very careful to leave in its place. You ſeem to diſcern the end of this labour. It is contrived for a private paſſage for the caterpillar to go out at, at the ſame time that it prevents the entrance of any miſchievous inſects. Our induſtrious caterpillar then makes a little door into its cell. The door is not to be opened till after the laſt metamorphoſis. The winding parts of it being interwoven with the leaf, it remains as it were ſubſervient to it. In iſſuing from the cone, the caterpillar deſcends by the whole length of the thread, which holds it ſuſpended; it follows the direction of it, arrives at the door, and burſts it open by puſhing its head againſt it. Theſe coffins, which you ſee pierced through, have been abandoned by the caterpillars.

29. Our grain is liable to be eaten by a very ſmall inſect, that lodges within it, and is there metamorphoſed. The covering of corn is a kind of very cloſe box, which the caterpillar lines with ſilk. But the caterpillar is provided with no inſtrument to pierce through this box, and would remain priſoner therein, if the inſect were not inſtructed how to prepare a paſſage from it. It proceeds in the ſame manner as the roller of the aſh; it cuts with its teeth a little round place in the covering of the grain, which it is very careful not to diſengage entirely from it. The butterfly need only preſs againſt this part, in order to obtain its liberty.

In the centre of the capper thiſtle there is a large oblong cavity, which is commonly inhabited by a ſmall caterpillar, that makes a ſort of cone therein, where ſhe transforms herſelf. The rind of the thiſtle is much harder than that of our corn. It would be impoſſible

for the butterfly to force a paſſage through it. It would have occaſion for very ſtrong teeth for that purpoſe, and is furniſhed with no analogous inſtruments. The caterpillar, which ſeems ſenſible of this, makes a ſkilful proviſion for the neceſſities of the butterfly. It pierces in different parts the walls of its lodge, and makes a ſmall round hole in it, oppoſite the extreme part of the cone which the butterfly is to go out at. But, were this hole to remain open, the chryſalis would be too much expoſed. The caterpillar contrives a very ſimple expedient for ſtopping up the aperture. The whole exterior part of the head of the thiſtle is covered with the ſeeds of the plant. The caterpillar brings ſome of theſe little bodies to the outſide of the hole.

In treating of the proceedings of aquatic moths, we have remarked that they transform themſelves in their caſe. There muſt be a continual freſh ſupply of water in this encloſure: yet, no voracious inſect ſhould be allowed acceſs to it. Inſtead of placing a full made door at the entrance of its lodge, the moth puts a grated one there, which anſwers every end. Let us not attribute our method of reaſoning to this moth. Does ſhe know that voracious inſects have a deſign againſt her life? Is ſhe ſenſible that ſhe will put on a form under which ſhe will not be able to fly? No; ſhe is ignorant of all this; nor does it concern her to know it. She has been taught to ſpread threads that are capable of growth; ſhe does ſpread them, in ſo doing, ſhe provides by a machine againſt the inconveniencies which ſhe neither knows or can know. Judge on the ſame principle of other facts of this kind. It is always the Author of the inſect who alone is to be eſteemed wonderful.

30. I need not then endeavour, from the end which we diſcover in the work of an induſtrious animal, to find a reaſon for this work. I would not ſay, The ſpider ſpreads a net to catch the flies; but that the ſpider catches the flies becauſe ſhe ſpreads a net, &c. and ſhe forms a net, becauſe ſhe has occaſion to ſpin. The end is not leſs certain, or leſs evident; only, it is not the animal that has propoſed it, but the Author of the animal.

animal. What loſs would natural theology ſuſtain by this method of reaſoning? Would it not, on the contrary, acquire a greater degree of exactneſs? Let us reaſon then on the operations of animals as we do on their ſtructure. The ſame wiſdom which has conſtructed and arranged with ſo much art their various organs, and has cauſed them to concur to one determinate end, has likewiſe cauſed thoſe numerous operations, which are the natural effects of the œconomy of the animal, to contribute to one end. He is directed towards his end by an inviſible hand; he executes with preciſion, from the very beginning, the works which we admire; he ſeems to act as if he was capable of reaſoning, to turn about with propriety, and to change his method as there is occaſion, and in all this only obeys thoſe ſecret ſprings by which he is actuated; he is only a blind inſtrument that cannot judge of his own action, but is excited to it by that Adorable Mind which has traced out to every inſect his little circle, as he has marked out to each planet its proper orbit. When therefore I ſee an inſect working on the conſtruction of a net, a cone, or a chryſalis, I am ſeized with reſpect, becauſe I am beholding a ſight where the Supreme Artiſt is concealed behind the ſcene.

31. Many ſpecies of ſolitary bees content themſelves with penetrating into the earth; ſcoop out cylindrical cavities therein, and poliſh the walls. They depoſit an egg there and amaſs a ſufficient quantity of nouriſhment.

There is another ſpecies of theſe worms that pierce the earth, whoſe induſtry is much more remarkable. They do not content themſelves, like the others, with an entire naked cavity. On viſiting the inſide of the lodge, immediately after its conſtruction, we are agreeably ſurpriſed to ſee it hung quite round with tapeſtry of the moſt beautiful crimſon ſatin, affixed to the ſides as our tapeſtry is to the walls of our apartments, but with much more propriety. Thee bee does not only line in this manner the whole inſide of her dwelling; but alſo ſpreads the ſame kind of tapeſtry round

the

the entrance, to the diſtance of two or three lines. We have obſerved many caterpillars that line the inſide of their cone or encloſure with ſilk: our bee is the only inſect at preſent known, which properly ſpeaking, hangs her neſt with tapeſtry, as we do our apartments. It is therefore with good reaſon that this induſtrious animal has received the name of the tapeſtry-bee.

You ſeem at a loſs to know from whence ſhe procures the rich tapeſtry. Look at the flowers of this wild-poppy, which are newly blown: obſerve that they are ſloped here and there. Compare them with the tapeſtry whoſe tiſſue you are deſirous of knowing, you can find no difference between them: this tapeſtry is no other than the fragments of the flowers of the wild-poppy; and that is the ſecret origin of thoſe ſlopings you remark on the poppies that border upon the neſt. Your curioſity is not yet ſatisfied; you are deſirous of obſerving a little the labour of our ſkilful worker in tapeſtry.

The hole, which ſhe digs perpendicularly into the earth, is about three inches in depth. It is exactly cylindrical, as far as to ſeven or eight lines of the bottom. There it begins to open wider, which it does more and more. When the bee has made an end of giving it the ſuitable proportions, ſhe proceeds to line it with the tapeſtry.

With this view, ſhe applies herſelf to cutting, with abundance of art, pieces of petals * of an oval form from the flowers of the wild-poppy, which ſhe ſeizes with her legs, and conveys into her hole. Theſe little ſcraps of tapeſtry, when tranſported thither, are very much crumbled; but the tapeſtry-bee knows how to ſpread them out, diſplay them, and affix them to the walls with aſtoniſhing art.

She applies at leaſt two layers of the petals. She ſpreads two tapeſtries on each other. The reaſon of her furniſhing herſelf with it from the flowers of the wild-poppy, rather than from thoſe of many other plants, is, becauſe in them are united, to a higher degree, all thoſe

* This is the name given by botanists to the leaves of flowers.

qualities

qualities which are requiſite for the uſe to which the bee deſigns to put them.

When the pieces which the bee has cut and tranſported are found to be too large for the place they are intended to occupy, ſhe cuts off the ſuperfluous parts of them, and conveys the ſhreds out of the apartment.

After hanging the tapeſtry, the bee fills the neſt with paſte, to the height of ſeven or eight lines. This is all that is neceſſary for the nouriſhment of the worm. The tapeſtry is deſigned to prevent the mixture of particles of earth with the paſte.

You expect undoubtedly that the prudent bee ſhould not fail to cloſe up effectually the aperture of the neſt, in order to hinder the acceſs of thoſe inſects into it that are fond of the paſte: this ſhe takes proper care to do: and it is utterly impoſſible for you to diſcover, from the ſurface of the ground, the ſpot where the neſt was, whoſe conſtruction you have juſt been contemplating, ſuch is the ſkill employed by the bee in cloſing it. This little white pebble was at the edge of the hole, or very near it; it has not changed its place, and indicates to us the part beneath which the neſt is we are ſearching for. It ſeems then as if we ſhould have nothing more to do than to raiſe up a light layer of earth, in order to expoſe to view the entrance of the hole, which has been ſo well cloſed. Nothing can be eaſier or leſs doubtful. How great is your ſurpriſe! you have already taken up two or three inches of the earth in depth, and you cannot find the leaſt appearance either of the hole or the tapeſtry. What can this mean? What is become of the neſt that was ſo ſkilfully conſtructed, ſo properly lined, and was upwards of three inches deep? A few hours ſince, you admired the ingenious contrivance of it, and now the whole has diſappeared, ſo that you cannot diſcover the leaſt trace of it. What myſtery then is this? It is effected as follows:

When the bee has done laying, and amaſſed her quantity of paſte, ſhe takes down the tapeſtry, folds it over the paſte, which ſhe wraps together in it pretty nearly as we fold on itſelf a coffin of paper that is half full. The egg and paſte are by this means encloſed within a little bag of flowers. The bee has then nothing

farther

farther to do, but to fill up with earth all the void ſpace that is above the bag; and this ſhe performs with ſuch wonderful activity and exactneſs, as utterly to conceal the place where the neſt was.

If a hare does not poſſeſs, like the rabbit, the art of digging for himſelf a burrow, he does not however want a ſufficient degree of ſagacity to enable him to ſecure himſelf, and eſcape from his enemies. He can chooſe for himſelf a form, and conceal himſelf betwixt clods of earth that reſemble the colour of his hair. In winter, he takes up his lodging to the ſouth, and in ſummer time to the north; when ſtarted by the dogs, he purſues the ſame track for ſome time, goes the ſame way back again, darts aſide, throws himſelf into a buſh, and there ſquats down. The pack follow the path, paſs before the hare, and loſe ſcent of him.

The crafty animal ſees them paſs by and run far from him, he iſſues from his retreat, confounds his courſe, and puts the hounds to a loſs. He varies his ſhifts continually, and always conducts them as his circumſtances require. Sometimes at the cry of the hounds, he quits his form, ſpeeds away to the diſtance of a quarter of a league, caſts himſelf into a pond, and lies hid among the ruſhes. At others he mingles with a flock of ſheep, and will not abandon them. One time he conceals himſelf under ground: at another leaps under a ruinous wall, couches among the ivy, and lets the dogs paſs him. Oftentimes he runs along one ſide of a hedge, whilſt the dogs go on the other. Sometimes by ſeveral efforts he ſwims acroſs a river. Laſtly, at others he obliges another hare to quit the form, in order to ſupply his place, &c.

The ſtag, which by the elegance and lightneſs of his make, by thoſe living branches with which his head is rather adorned than armed, his ſize, ſtrength, and noble air is one of the grand ornaments of the foreſt, is endued with more ſubtlety than even the hare, and finds more exerciſe for the ſagacity of the huntſman.

When purſued by the hounds, he paſſes and repaſſes ſeveral

ſeveral times on his track; eludes their purſuit by aſ ſorting himſelf with other beaſts, darts forward, and immediately flees to a diſtance, ſtarts aſide and ſteals away, and lies proſtrate on his belly. The land betraying him every where, he betakes himſelf to the water. The hind that nouriſhes her young, preſents herſelf to the dogs, in order to facilitate the eſcape of her young, ſhe runs away with ſwiftneſs, and afterwards returns to it.

32. The fox, celebrated for his ſubtilty, is no leſs circumſpect than ſkilful, no leſs vigilant than crafty, he weighs cautiouſly the leaſt of his meaſures, ſtudies circumſtances, watches inceſſantly, and has always ſome contrivance in reſerve to aſſiſt him upon an exigency. His genius ſo fruitful in reſources, multiplies almoſt to infinity his ſhifts and ſtratagems.

Though extremely fleet in running, he does not truſt to his natural ſwiftneſs: he judges that that alone would not be ſufficient for his preſervation. He works for himſelf a timely aſylum under ground: where he takes refuge in caſe of neceſſity, and lodges, and brings up his family.

He eſtabliſhes his dwelling place on the border of woods, and in the neighbourhood of farm-houſes. He liſtens afar off with an attentive ear to the cackling of poultry, directs his ſteps accordingly, arrives by ſeveral winding ways, ſquats himſelf down, paſſes along on his belly, lies in ambuſcade, and rarely fails in his attempt.

If he is ſo happy as to penetrate into the encloſure, he employs to good purpoſe every moment of his time, and ſlaughters the whole ſtock. He immediately retreats, carries away with him one of the prey, conceals it, returns in ſearch of another, hides that like the former, and does not ceaſe from plundering, till he perceives he has been diſcovered.

He is amazingly ſkilful in hunting young leverets, ſurpriſing the hares when lying down; in diſcovering the neſt of partridges, or quails, and ſeizing the mother on her eggs.

Equally bold as crafty, he has even the courage to

attack bees: he attempts to get their honey, which he is very fond of. Theſe warlike inſects preſently aſſail him on all ſides, and in a few moments he is entirely covered with them. He retires ſome paces, rolls himſelf on the ground, cruſhes them by that means, returns to the charge, and at length obliges this little laborious people to abandon to him the fruits of their long labours.

I ſhall add but one more inſtance; if the fox diſcovers that his young have been diſturbed during his abſence, he tranſports them one after another to a new place of retreat.

The following is the concluding paragraph of volume the fourth of the former edition.

I have preſented my readers with a variety of facts of an intereſting nature, ſufficient to enable them to form an idea of thoſe pleaſures which reſult from the contemplation of nature. But this contemplation would prove fruitleſs, did it not lead us to aſpire inceſſantly after this adorable Being, by endeavouring to acquire a knowledge of him, from that immenſe chain of various productions wherein his power and wiſdom are diſplayed with ſuch diſtinguiſhed luſtre. He does not impart to us the knowledge of himſelf immediately; that is not the plan he has choſen; but he has commanded the heavens and the earth to proclaim his exiſtence, to make him known to us. He has endued us with faculties ſuſceptible of this divine language, and has raiſed up men who explore their beauties, and become their interpreters. Impriſoned for a while in a ſmall obſcure planet, we only enjoy ſuch a portion of light as is ſuitable to our preſent condition: let us wiſely improve each glimmering ray reflected upon us, nor loſe the ſmalleſt ſpark: let us continually advance in this Effulgent Light! A time will come, when we ſhall draw all light from the Eternal Source of Light, and inſtead of contemplating the Divine Architect in the works of his hands, ſhall contemplate the workmanſhip in the Omnipotent Author thereof. "We now ſee things as through a glaſs darkly; but we ſhall then ſee face to face."

HAVING

HAVING by reason of the largeness of the preceding volumes, which contain much more than I expected, some pages to spare, I am well pleased with an opportunity of inserting here, another extract from one of the most ingenious treatises, which, I believe, was ever wrote upon the subject: Mr. Deutens' "Enquiry into the origin of the discoveries attributed to the Moderns." I am surprised that I never heard of it till very lately; and I have met with exceeding few that have: although the Latin original (I suppose, for I have not seen it) has been published good part of twenty years, and the elegant and judicious translation of it was printed eight or nine years ago. It is true, I am hereby convinced of several mistakes, which I had been in for many years. But I look upon every such conviction as a valuable acquisition. And I trust, my heart will always say, both to God and man, "What I know not, teach thou me."

The AUTHOR's PREFACE.

IN the compariſon between the moderns and ancients, a diſtinction ought to be made between the arts and ſciences, which require long experience and practice to bring them to perfection, and thoſe which depend ſolely on talent and genius. Without doubt, the former in ſo long a ſeries of ages have been extended more and more, and brought to a very high degree of perfection by the moderns, who in this reſpect ſurpaſs the ancients, though the art of printing, and many other diſcoveries, have not a little contributed to it. We know the aſtronomers in our days underſtand much better the nature of the ſtars, and the whole planetary ſyſtem, than Hipparchus, Ptolemy, or any other of the ancients. But it may be doubted whether they had gone ſo far, unaided by teleſcopes. The moderns have certainly perfected the art of navigation; nay, and diſcovered new worlds: but yet without the aſſiſtance of the compaſs, America in all probability had ſtill remained unknown. Likewiſe by long obſervation and experiments often repeated, we have brought the arts of botany, anatomy, and chirurgery, to the degree of perfection we now behold them in.

Many

Many ſecrets of nature, not to be penetrated in one age, have been laid open in a ſucceſſion of many. Morality itſelf hath been perfected by the Chriſtian Religion; philoſophy hath aſſumed a new air: and the trifling, childiſh, and vain cavils of the ſchools, have at length been put to flight by the reiterated efforts of Ramus, Bacon, Newton, and many others.

I willingly therefore give up to the partizans of the moderns every advantage I have here enumerated; but there is no need on that account to rob the ancients of the ſhare they have had in promoting all theſe parts of knowledge, by the pains they took to beat out for us the tracks we have purſued. Much leſs ſhould we aſſume, as modern diſcoveries, what the ancients really invented, or illuſtrated. It alſo deſerves notice, that the moſt part of the admirable and uſeful inventions, in which our age glories, ſuch as printing, gunpowder, the compaſs, teleſcopes, &c. were not the acquiſitions of genius and philoſophy, but mere effects of chance. To place in its true light the ſhare the ancients have in whatever we pretend to know, and even in what has been called modern diſcoveries, is the principal aim of my preſent undertaking.

CHAP. I.

Of the Circulation of the Blood, and the Fallopian Tubes.

1. THE medical art affords ſtriking inſtances of the injuſtice done to the ancients in endeavouring to deprive them of the glory of having made the moſt important diſcoveries in it. I ſhall produce two or three manifeſt proofs of this, and doubt not but the reader will perceive not only probable hints, but demonſtrative evidence, that the ancients clearly taught what we now diſpute their having had any knowledge of

2. It is remarkable with regard to medicine, that none of the ſciences ſooner arrived at perfection; for in the ſpace of two thouſand years, elapſed ſince the time of Hippocrates, there has ſcarcely been added a new aphoriſm to thoſe of that great man, notwithſtanding all the application of ſo many ingenious men, as have ſince ſtudied that ſcience.

3. I omit taking notice of ſome modern authors, who have endeavoured to prove, that the circulation of the blood was known to Solomon, that I may paſs to the more evident proofs of this diſcovery, which Hippocrates furniſhes us with. After examining thoſe paſſages, no one will deny but this able phyſician knew, what he expreſſes ſo clearly.

4. In truth, it is hard to conceive that he knew nothing of the circulation of the blood, when we hear him

him ſay, "That all the veins communicate one with the other, and run into one another: that the veins which ſpread themſelves over the whole body, filling it with ſpirit, juice, and motion, are all of them but branches of one original vein. I proteſt, I know not, ſays he, where it begins, or where it ends, for in a circle there is neither beginning nor ending." A little further he ſays, "that the heart is the ſource of the arteries, which carry blood into all parts of the body, communicating to them life and heat;" he adds, "that they are the rivulets which cheriſh the human body, and convey life to every part of man." In another part, he ſays, that the "heart and veins are always in motion." He compares the courſe of rivers, which return to their ſources in an unaccountable and extraordinary manner, to the circulation of the blood. In apoplexies and ſuch like diſorders, which he aſcribes to obſtructions in the veins, he preſcribes bleeding, in order to procure a free motion to the blood and ſpirits. He ſays alſo, that when the bile enters into the blood, it breaks its conſiſtence, and diſorders its regular courſe. He compares its admirable mechaniſm to clews of thread, whoſe filaments overlap each other; and ſays, that in the body it performs juſt ſuch a circuit, always terminating where it began.

5. The next to Hippocrates is Plato, who ſpeaks with clearneſs of the circulation of the blood; for from the heart, he ſays, ſpring the veins and blood, which with rapidity carries itſelf into all parts; adding, that when the blood thickens, it flows with more difficulty through the veins. Ariſtotle too regards the heart as the origin and fountain of the veins and blood. He ſays, that from the heart there ariſe two veins, one on the right, and the other on the left ſide; and he was the firſt who called this aorta. He held that the arteries, had a communication with the veins, and that they were intimately connected together.

6. Julius Pollux, in his Onomaſticon, deſcribing all the parts of the body, and their uſes, among other things ſays, in ſpeaking of the arteries, that they are

"the

" the paſſages and canals of the ſpirits, as the veins are of the blood;" and in ſpeaking of the heart, he ſays, that it " hath two cavities, the one of which communicates with the arteries, the other with the veins." Apuleius in explaining the doctrine of Plato, ſpeaks likewiſe of the circulation of the blood, and in a few words deſcribes it as clearly as any of the moderns. It is true, he does not expreſsly mention, that the blood flows from the heart through the arteries; but on its leaving the heart, he ſuppoſes its courſe along the lungs, to ſpread itſelf afterwards into all parts of the body.

7. Nemeſius, biſhop of Emiſſa, who may be accounted among the ancients, having lived in the fourth century, has a very clear paſſage to this purpoſe, wherein he ſays, " that the motion of the pulſe owes its origin to the heart, and particularly to the left ventricle of that viſcus. The cordiac artery expands and contracts itſelf with very much force, but always with great regularity and harmony of motion. In its expanſion it draws in the moſt ſubtle parts of the blood from the adjoining veins, and of that blood forms the aliment of the vital ſpirits: and in its contraction exhales all the fumes brought into it by ſecret paſſages from all parts of the body."

8. It appears from what we have ſaid, that the circulation of the blood was known to the ancients; though they did not expatiate upon it; and what reduces to a very ſmall degree the honour that Hervey can claim, in making that diſcovery, is that Servetus had treated of it very diſtinctly before him, in the fifth part of his book De Chriſtianiſmi Reſtitutione; a work ſo very ſcarce, that there are but few who can boaſt of having ſeen it in print. Mr. Wotton, in his Reflections upon the Ancients and Moderns, cites this paſſage of Servetus: in which he diſtinguiſhes three ſorts of ſpirits of the human body, and ſays, that blood, " which he calls a vital ſpirit, is diſperſed through the body by the anaſtomoſis, or mutual inſertion of two veſſels, at their extremities, into one another." Where

it

it deſerves obſervation, that Servetus is the firſt who employed that term to expreſs the communication between the veins and arteries. He makes the "expanded air in the lungs contribute to the formation of blood, which comes to them from the right ventricle of the heart, by the canal of the pulmonary artery. He ſays, that the blood is there refined and perfected, by the action of the air, which ſubtilizes it, and blends itſelf with that vital ſpirit, which the expanded heart then receives as a fluid proper to carry life every where. He maintains, that this conveyance and manner of preparing the blood in the lungs, is evident from the junction of the veins with the arteries in this viſcus. And he concludes with ſaying, that the heart having received the blood thus prepared by the lungs, ſends it forth again by the artery of its left ventricle, called the aorta, which diſtributes it into all parts of the body." Andreas Ceſalpinus, who lived likewiſe in the ſixteenth century, hath two paſſages which completely contain all that we know about the circulation of the blood. "He explains at length how the blood guſhing from the right ventricle of the heart through the pulmonary artery, to paſs into the lungs, enters by an anaſtomoſis into the pulmonary veins to be conveyed to the left ventricle of the heart, and afterwards diſtributed by the aorto into all parts of the body."

9. Johannes Leonicenus ſays, that the famous Paul Sarpi, otherwiſe named Father Paul, was he who diſcovered the circulation of the blood, and firſt diſcerned the valves of the veins, which like the ſuckers of a pump, open to let the blood paſs, but ſhut to prevent its return; and that he communicated this ſecret to Fabricius ab Aquapendente, Profeſſor of Medicine, at Padoua, in the ſixteenth century, and ſucceſſor to Fallopius; who diſcovered it to Hervey, at that time ſtudying phyſic under him in the Univerſity of Padoua.

10. There is another important diſcovery in Anatomy, attributed to Fallopius, which had a more ancient origin; I mean the two ducts which inſert themſelves into the ſides of the womb, and ſerve to convey the

the ſeed or female ſperm from the ovaries into the womb, and are called the Fallopian tubes, being ſhaped almoſt like a trumpet, and thought to have been diſcovered by Fallopius of Modena, who died in the year 1562. We find them deſcribed as follows, by Ruffus of Epheſus. "Herophilus, ſays he, imagined that females had no ſeminal veſſels; but in examining the womb of a beaſt, I found ariſing from the ovaries certain ducts, which entwiſted into each other, were entirely varicous, and at their farther extremity entered into the cavity of the womb. Upon compreſſing them, there iſſued from them a glutinous humour, and I am firmly perſuaded they are ſeminal veſſels of the very ſame ſtructure with thoſe in males called the varicous paraſtatæ."

CHAP. II.

Of the Chirurgery of the Ancients.

1. AS to the ſubject of this Chapter, I cannot entertain my reader better than by preſenting him with an extract of Mr. Bernard's Thoughts upon it, who was firſt Surgeon to King William. Here follows a faithful tranſlation of part of a memoir, which he imparted to his friend Mr. Wotton.

2. "If we attend well to what the moderns have added to the ſurgery of the ancients, we ſhall be obliged to own, that we have not the leaſt right to deſpiſe them, as thoſe do who know nothing of them, nor have ever read them; and who give the ſtrongeſt proofs of their own ignorance and pride, in the manner wherein they preſume to treat thoſe great men. I do not ſay, that the moderns have in no reſpect contributed to the advancement of ſurgery; but what I ſay is this, that the

the merit of the moderns conſiſts rather in having reintroduced the inventions of the ancients, and ſet them in a better light, than in any important diſcoveries that they themſelves have made in this ſcience. Whether the art of curing wounds, falling immediately under the obſervation of ſenſe, has for that reaſon been the ſtudy of the men of the earlieſt times, and by that means ſooner acquired a degree of perfection, than the other branches of medicine: or that the moſt part of thoſe who afterwards aſſumed the profeſſion, were mere empirics, and ignorant of it: which ever of theſe be the caſe, it is certain this art has not for ſome ages paſt been cultivated, as it might have been: and to prove this, we need only to reflect how few the number of good writers are upon this ſubject, in compariſon of thoſe who have written upon other branches of the arts and ſciences. Whoever is converſant with the writings of the ancients, and has ſkill to judge of their merit in his own practice, will ingenuouſly own, that what renders the reading of them more uſeful than thoſe of the moderns, is, that they are more exact in deſcribing the ſymptoms and indications of diſorders, and more juſt and preciſe than the moderns, in diſtinguiſhing the different ſpecies of ulcers and tumors. If our age has retrenched ſome ſuperfluities of practice, and it muſt be owned it has; yet it cannot be ſhewn that theſe methods came from the ancients. It is much more probable, that they were in a great meaſure introduced by the ignorant profeſſors of a later date. There is no doubt but the perfection to which ſurgery has been carried in theſe laſt ages, is principally owing to the diſcoveries which have been made in anatomy, by means of which we are enabled to give a reaſon for many of the phenomena, which were before inexplicable. But the moſt eſſential part, the art of curing wounds, to which all the other part ought to give way, remains almoſt in the very ſame ſtate, in which the ancients tranſmitted it to us. What I have ſaid is inconteſtable: and for proof of it, I appeal to every courſe of ſurgery that has been publiſhed by the moſt celebrated among the moderns, all of which appear to be but tranſcripts of one another, excepting thoſe of the

greateſt

greateſt note which are taken from the ancients. Among all the writers of ſyſtems, few deny the pre-eminence to Fabricius ab Aquapedente, a man of exquiſite learning and judgment, but who is not aſhamed to declare that Celſus among the Latins, Paul Eginetus among the Greeks, and Albucaſis among the Arabians, are thoſe to whom he is moſt indebted in the compoſition of his excellent work. But it will be ſaid, that a great many methods of operation are at preſent in uſe, which were unknown to the ancients. I fear, on the contrary, that an impartial examination into this would diſcover many more, and of greater utility, either omitted or diſcontinued, than of new, which we have introduced: provided their inquiry were entered upon with an impartial and unprejudiced mind.

3. "To begin with the operation of the ſtone, there is nobody doubts but they have a right to claim that as their own. Celſus and many others have given us exact deſcriptions of it; though it muſt be owned that the method of operation, deſerving the preference in many reſpects, and known by the name of the grand operation, was the invention of Johannes de Romanis, of Cremona, who lived at Rome in the year 1520, and publiſhed his work at Venice in 1535. The inſtrument that we make uſe of in trepanning, was doubtleſs firſt uſed by the ancients, and only rendered more perfect by Woodall and Fabricius ab Aquapendente. Tapping likewiſe is in all reſpects an invention of theirs. Larnygnotomy, or the opening of the larynx in the quinſey, was practiſed by them with ſucceſs; an operation which, though ſafe and needful, is almoſt out of uſe at preſent.

4. "The cure of the Hernia inteſtinalis, with the diſtinguiſhing differences of the ſeveral ſpecies of that malady, and their method of cure, are exactly deſcribed by the ancients. It was they who taught us the cure of the pterygion and cataract, and treated the maladies of the eye as judiciouſly as any of our modern oculiſts, who, if they would act with honour, ſhould confeſs, that they do nothing more but practiſe

over

over again what thoſe great maſters taught. The opening of an artery and of the jugular vein is no more a modern invention, than the application of the ligature in the caſe of an aneuriſm, which certainly was not well underſtood even of late by Frederic Ruyſch, that celebrated anatomiſt of Holland. The extirpation of the amygdales, or of the uvula, is not at all a late invention, though it muſt be owned the efficacious cauteries now uſed in the caſe of the former, were neither practiſed nor known by the ancients. The method we now uſe of treating the fiſtula lacrymalis, a cure ſo nice and difficult, is preciſely that of the ancients, with the addition that Fabricins made of the cannula for applying the cautery.

5. "As to the real cauſtic, which makes a conſiderable article of ſurgery, although Caſteus, Fienus, and Severinus, have written amply on that ſubject; yet it is evident from a ſingle aphoriſm of Hippocrates, that this great phyſician knew the uſe of it as well as thoſe who have come after him: and beſides it is frequently ſpoken of in the writings of all the other ancients, who without doubt uſed it with great ſucceſs in many caſes where we have left it off, or know not how to apply it. The cure of the varices by inciſion, ſcarcely ſo much as made mention of now, appears to have been a familiar practice among the ancients, as is manifeſt from the works of Celſus and Paulus Eginetus; and whoever is converſant in the treatment of varicous ulcers, will agree that this operation is abſolutely neceſſary, for the effectual cure of them. The polypus o the ear is a malady ſo little underſtood by the moderns, that we meet but very rarely with the name it in their writings; and yet the deſcription of its cure has not been omitted by the ancients. They were entirely well acquainted with all kinds of fractures and luxations, and the means of remedying them; as well as with all the ſorts of ſutures in uſe amongſt us, beſides many which we have loſt. And though ſome have advanced, that cauteries were unknown to them, we may eaſily convince ourſelves of the contrary by obſerving what Celſus and Cœlius Aurelianus have ſaid of them,

allowing

allowing, withal that they ſeem not to have known our method of placing and continuing them.

6. " Nor ought I to omit what is ſo manifeſt, that nobody will deny it, that all ſorts of amputations, as of limbs, breaſts, &c. were performed among them as frequently, and with as great ſucceſs as we can pretend to. As to the art of bandaging, ſo very important and neceſſary, though much neglected at preſent, and which the French ſo much pique themſelves upon, as if in this they excelled all others; the ancients knew it to ſuch a degree of perfection, that we do not even flatter ourſelves without having added any thing conſiderable to what Galen hath taught us, in the excellent tract he was writ on this ſubject. And although the moderns claim an advantage over the ancients, in regard to the variety of their inſtruments, it is nevertheleſs evident, that they were ignorant and deſtitute of none that were neceſſary: nay, it is highly probable, from what Oribaſius, nay and many others have ſaid, that they had great variety of them. As to topics, or the remedies which are externally applied, it is certain that we are indebted to them, for having inſtructed us in the nature and properties of thoſe we now uſe; and as to general methods of cure, the ancients have ſo eminently excelled, particularly in that of treating the wounds of the head, that thoſe of the moderns who have written moſt judiciouſly upon it, though they could do no better ſervice to poſterity, than comment upon that admirable book which Hippocrates wrote on this ſubject.

7. " It would require more leiſure and ability than I have, concludes Mr. Bernard, to enter into a detail of more particulars, and ſhew what hath been invented, ſet aſide, or loſt in different ages. What I have already advanced ſufficiently makes it appear, that we ought to talk of the ancients with great reſpect; not that we ſhould blindly yield to their authority, or imagine that they left nothing to be perfected in following ages; but we ought to imitate the celebrated Bartholin. We make but an ill judgment of our own intereſt,

intereſt, ſays that great man, when we ſo plunge ourſelves in the ſtudy of the moderns, as to neglect or contemn that of the ancients, whoſe writings are ſo neceſſary to throw light upon every part of the ſcience. And in another place he ſays, I have always ſhewn a particular regard to the opinions and maxims of the moderns, yet never without paying due homage to antiquity, to which we are indebted for the very prime foundations of our art."

CHAP. III.

Of Generation.

1. THERE are two principal ſentiments among the moderns, relative to the manner in which generation is effected. Some think that all the parts of the fœtus are encloſed in miniature in thoſe eggs contained in the ovaries of the female, which communicate with the womb by the Fallopian tubes; and that the ſeed of the male is only a ſort of matter proper for detaching the egg, cheriſhing it, and conveying it into the womb, where the germ contained in the egg afterwards unfolds its parts: this is the ſentiment of Hervey, Red, and many other celebrated phyſicians, who maintain that all animals are oviparous, and ſpring from eggs, which in the animal kingdom are what ſeed is in the vegetable.

2. The other ſentiment is that of Lewenhoek, that all animals, and even men, ſpring from little animals of extreme minuteneſs, contained in the ſeed of the male; and he looks upon the eggs in the ovary of the female only as little niduſes fit to receive theſe animalcula,

cula, and to contribute to their developement and increaſe, by imparting to them the nouriſhment which comes from the veſſels of the womb.

3. The firſt of theſe ſyſtems was for a time generally received, and appeared to be founded on juſt obſervations. Thoſe who maintain it declare, that they have found eggs in the ovaries of every female that came under their notice, often to the number of more than twenty in each ovary, and of the ſize of a green pea. They draw another of their arguments from the analogy that nature every where obſerves in all her operations, and particularly in the production of plants and animals. Now if this ſyſtem deſervedly confers glory on the inventer of it, it is but juſt that he ſhould have it who is beſt entitled to it; and he to whom it appears primarily due is without doubt Empedocles, and next to him Hippocrates, Ariſtotle, and Macrobius.

4. Plutarch relating the different opinions of philoſophers, as to the generation of animals and productions of plants, ſays, that Empedocles thought they were all of them at firſt irregular and imperfect, but acquired afterwards ſuch a juſt form as diſtinguiſhed them in ſhape and ſpecies from one another. And he concludes with ſaying, that animals are not produced, like earth and water, from homogeneous bodies; but generate one another by the mixture of the ſexes, and like plants derive the principle of their origin from the particular ſeeds or eggs. This is the very ſame which Ariſtotle intended to indicate as the doctrine of Empedocles, when he introduces him as ſaying, "That whatever was born, was born of a particular ſeed;" and as calling the ſeeds of plants their eggs, which fall of themſelves when they are come to maturity.

5. Herodotus, who lived almoſt at the ſame time with Empedocles, relating that a land adjoining to the Nile had produced a great quantity of fiſh, gives a natural reaſon for it, upon the principles of Empedocles.

What

What ſeems to me, ſays he, to have been the cauſe of this vaſt increaſe of fiſh, is this: during the time of the Nile's overflowing, the fiſhes having left in the mud of its borders a prodigious quantity of ſperm or eggs, theſe diſcloſe themſelves after its retreat, covering the land with a multitude of fiſh.

6. Hippocrates, ſpeaking of the formation of an infant, deſcribes a fœtus ſix days old, comparing it to a raw egg without the ſhell, round and full of a red tranſparent liquor. In another place, he ſhews "how the ſame thing happens in the generation of an infant, as in the production of a plant." He ſays, "that nature is always the ſame, acting uniformly in the generating of men, and of plants, and of every thing elſe."

7. Ariſtotle with ſtill more preciſion, deſcribes the egg containing the fœtus—He ſays, "that all animals engender and conceive firſt a kind of egg, containing a liquor enveloped in a membrane or thin ſkin, reſembling that of an egg-ſhell." This, in another place, he plainly calls an egg; out of one part of which, he ſays, "the fœtus is produced; that is, out of the yolk; whilſt the white part, which is the other, ſerves to nouriſh it."

8. Nothing can be more clear than what Macrobius pronounces on this ſubject, who poſitively avers, that of all kinds of animals who copulate, an egg is the firſt principle of their generation; and in another place, that the egg is the ſolution or expanſion of the ſeed.

9. The ſyſtem of animalcules or ſpermatic vermiculi has hindered that of generation by the means of eggs, from gaining the unanimous ſuffrage of the naturaliſts. Mr. de Plantades, ſecretary of the academy of Montpelier, was the firſt among the moderns who renewed this conjecture of the ancients. Lewenhoek and others confirmed this conjecture by obſervations ſo accurate, that they divided the ſentiments of natura-

liſts between their own opinion of men's proceeding from ſpermatic animalcula; and that of Hervey, which derives all generation from eggs. We have already ſeen that this latter opinion ſprung from Hippocrates, Ariſtotle, &c. And the other, of the exiſtence of ſpermatic vermiculi, is as clearly taught by Plato, Hippocrates, Ariſtotle, and other ancient philoſophers, as if they had ſeen them. We can never ſufficiently extol the extreme penetration of thoſe great geniuſes, who, guided ſolely by reaſon, arrived ſo long before us, where we, after all our nice experiments and laborious reſearches, are glad to reſt.

10. Democritus is the firſt of the Grecian philoſophers, who hath ſpoken of certain worms, which aſſume at length the human form; but no author tranſmitted to us, hath entered into a detail of this opinion; though Epicurus, Diodorus Siculus, and Euripides ſeem to hint at it. Epicurus thought that the generation of animals was effected by the continual transformation of one into another. Anaxagoras had ſaid the ſame, as well as Euripides quoted by Plutarch, Galen, Euſebius, and Philo. But Democritus, in explaining himſelf more preciſely, taught, that men, in their firſt original, appeared in the form of ſmall worms, which in all probability, he conceived to be contained in the ſeminal juice of the male; for it is natural to ſuppoſe, that in this idea he agreed with Hippocrates, who inſinuates, that the ſeed of animals is filled with animalcula, whoſe parts unfold themſelves and grow all at a time.

11. That illuſtrious phyſician without all doubt held conferences upon this ſubject with Democritus, whom he found engaged in the deſection of animals when he went firſt to viſit him, and long enjoyed the utmoſt ſatisfaction in his company upon matters entirely philoſophical. Ariſtotle ſeems to hint at Democritus, when treating of the firſt formation of men, he ſays, that ſome have thought that the firſt men, after having ſprung out of the earth, began their exiſtence in the form of little worms; and in another place he ſpeaks

of

of Democritus as having believed, that in the generating of man the exterior parts of the fœtus are firſt formed; ſo that it is even then of human ſhape, and therefore even in that condition may be looked upon as a little man.

12. Hippocrates advanced, that nothing in nature abſolutely periſhed; that nothing, taking it altogether, was produced anew; nothing born but what had a prior exiſtence; that what we call birth, is only ſuch an enlargement as brings from darkneſs to light, or renders viſible thoſe ſmall animalcula which were before imperceptible. He ſays a little farther, it is impoſſible that what is not ſhould be born, there being nothing that can contribute to the generation of what has no exiſtence. But he maintains, that every thing increaſes as much as it can, from the loweſt to the higheſt degree of magnitude. Theſe principles he afterwards applies to human generation. He ſays, "that the larger ſizes ariſe out of the leſſer; that all the parts ſucceſſively expand themſelves, and grow and increaſe proportionally in the ſame ſeries of time; that none of them in reality takes the ſtart of another, ſo as to be quicker or ſlower in their growth; but that thoſe which are naturally larger, ſooner appear to the eye than thoſe which are ſmaller, though they by no means preceded them in exiſtence." In ſhort, in the beginning of this book of Hippocrates, we meet with a train of reaſoning entirely juſt and ſolid, the natural conſequences of which is, that at the beginning of the world the ſeeds containing the firſt lineaments of plants and animals came into exiſtence, though their extreme minuteneſs hinders them from being ſeen. Whence he concludes, as we have already had occaſion to obſerve, that the birth of animals is only ſuch an enlargement of them, as makes them paſs from darkneſs into light.

13. It may be objected, that we have already repreſented Hippocrates and Ariſtotle as favouring the ſyſtem of generation by eggs; and that we now ſeem to aſcribe a contrary opinion to them. But it ought to be

 remarked,

remarked, that in reality theſe two philoſophers favoured the former ſyſtem: for Ariſtotle only relates the other opinion as introductory to the eſtabliſhment of his own; and Hippocrates contents himſelf with inſinuating the notion, that there may be animalcula in the male ſeed, without taking it upon him to eſtabliſh it as a truth. Beſides, he might have admitted of ſpermatic vermiculi in the ſenſe that ſome moderns do, in order to reconcile the two ſyſtems, regarding the eggs as niduſes proper for the reception of the ſpermatic vermiculi, and containing matter neceſſary for contributing to their growth. In this caſe the ſpermatic worm will be the real fœtus, the ſubſtance of the egg is nouriſhment, and the membranes of it its wrappers.

14. Plato hath ſtill more clearly ſpoken of thoſe ſmall animals which become men; for after having compared the womb to a fertile field, in which the ſcattered ſeed produces fruit; he ſays, "that the animalcula, which there receive their growth, are at firſt ſo extremely ſmall as not to be perceptible to the eye, but coming gradually to unfold themſelves and expand, by means of the food prepared for them in the womb, they afterwards ſpring forth into day in all the perfection of birth." Nor can it be denied that Seneca had a very diſtinct idea of this ſyſtem of human generation by animalcula, when we find him teaching, that "the human form before birth was compriſed in the ſeed, where all the members of the body were concentered and ſhrouded up in a little indiſcernible place:" Which Tertullian hath expreſſed in a few words, when he ſays, the ſeed hath life in it from the very firſt.

15. The diſcovery reſpecting the multiplicity of animation of which the polypus is capable, is what nobody makes any difficulty of regarding as due to the moderns, though Ariſtotle and St. Auguſtine ſpeak of it as clearly as any of the moderns, as a thing which they knew from their own experience. The latter relates in his book concerning the dimenſion of the ſoul, that one of his friends performed the experiment before

fore him, cutting a polypus in two; and that immediately the two parts thus ſeparated betook themſelves to flight, moving the one one way, and the other another. That great man adds, that this experiment ſuddenly threw him into ſuch amazement, that for ſome time he knew not what to think of the nature of the ſoul. Ariſtotle, ſpeaking of inſects, ſays almoſt the ſame thing; for without naming the creature he ſpeaks of, he obſerves, "that there are of theſe animals or inſects, as well as of plants and trees, that propagate themſelves by ſhoots:" and as what were but the parts of a tree before, become thus diſtinct and ſeparate trees: ſo in cutting one of theſe animals, ſays Ariſtotle, the pieces which before compoſed but one animal, become of a ſudden ſo many different individuals.

CHAP. IV.

Of the Sexual System of Plants.

1. NOBODY at preſent doubts but that plants propagate themſelves, as animals do, by means of organs, ſome male and others female; that in a great many plants theſe two kinds of organs are found united, which plants are then among naturaliſts diſtinguiſhed by the name of hermaphrodites; and that in other plants the two ſexes are ſo ſeparated, that the male are on one ſtem, and the female on another. This ſyſtem is founded, firſt, on the analogy there is between the eggs of the animals and the ſeed of plants, both ſerving equally to the ſame end, that of propagating a ſimilar race: ſecondly, on the remarks that have been made, that when the ſeed of the female plant is not impregnated with the prolific powder of the male, it bears no fruit; inſomuch that as often as the communication between the ſexual parts of plants has

has been intercepted, they have always proved barren. The authors of this ſyſtem, after exactly anatomizing all the parts of the plant, aſſign to each a name, founded on its uſe and analogy to the parts of an animal. Thus as to the male organs, the filaments are the ſpermatic veſſels, their antheres, or tops, the teſticles; and as to the female, the ſtyle anſwers to the ragina, the germ to the ovary, and the pericarpium, or fecundated ovary, to the womb.

2. Linnæus has the honour of having completed this ſyſtem, by reducing all trees and plants to particular claſſes, diſtinguiſhed by the number of their ſtamina, or male organs. Zaluzianſki ſeems to have been the firſt among the moderns, who clearly diſtinguiſhed from one another the male, the female, and the hermaphroditical plants. About a hundred years after him, Sir Samuel Millington and Dr. Grew communicated to the Royal Society of London, their obſervations on the impregnating duſt of the ſtamina. Camerarius, towards the end of the laſt century, obſerved, that upon plucking off the ſtamina of ſome male plants; ſuch as the mulberry-tree or the maize, the buds that ought to have produced fruit, came not to maturity. Malphighi and Vaillant have alſo carefully conſidered this fecundating duſt; the latter of whom ſeems to have been the firſt eye-witneſs of this ſecret of nature. Many authors afterwards applied themſelves to improve this ſyſtem.

3. We are now to examine whether the ancients knew any thing of this, or whether they only ſpeak of it in a vague and indeciſive manner. I agree, that they do not give ſo exact an account of the anatomy of every part of the flower of a plant as the moderns do; at leaſt, no ſuch work of theirs hath reached our times. They are even ſometimes ſo far miſtaken, as to apply ſome of the parts to purpoſes they do not ſerve. But in this they are more excuſeable than ſome of our ableſt moderns, who have fallen into great errors on this ſubject, notwithſtanding all the inſtructions, experiments and obſervations of their cotemporaries. The

ableſt

ableſt botaniſt of his age, Mr. de Tournefort, who could not be ignorant of what had been advanced by Millington, Grew, Malphighi, and Camerarius, yet maintains, that the ſtamina of flowers ſerve only to ſecrete or void the leſs uſeful parts of the nutritive juices, and are only the excretory veſſels belonging to the calix of the flower.

4. Having made this conceſſion, I may with the more ſafety affirm, that, this one circumſtance excepted, of which I have here made mention, the ancients perfectly underſtood the ſexual difference in plants, the fecundation of the fruits of the female by the duſt of the flowers of the male, and had a diſtinct idea of the two ſexes, as having place in different individuals.

5. Theophraſtus ſays, that trees may be diſtinguiſhed into ſeveral claſſes on account of their great variety; but that the moſt univerſal difference among them is that of their gender, whether male or female. And Ariſtotle obſerves, that we ought not to fancy that the intermingling of ſexes in plants is the ſame as among animals.

6. There were, it ſeems, various opinions among the ancients as to the manner in which plants ſhould be admitted to have a difference of ſex. Some looked upon them as complete in that reſpect, each individual containing in itſelf the power of both ſexes. Empedocles endeavoured to ſolve this, whether in plants the male was diſtinct from the female: or, whether the ſexes were united in each of the ſpecies: and he concluded, that plants were hermaphroditical; that is, a compoſition of both ſexes. Ariſtotle doubted, whether he ought to admit, that the two ſexes combined in the ſame plant, or ſhould pronounce that they exiſted ſeparately.

7. True it is, this author errs widely in his manner of diſtinguiſhing the male from the female plant; for he thought the difference to conſiſt in this, that the male

male was larger and ſtronger, the female weaker but more fruitful. He ſaid alſo that the male was more dry, and came ſooner to maturity than the female. But it ſhould be obſerved, it is not upon the teſtimony of Ariſtotle that we attempt to ſhew, the ancients knew the ſexual ſyſtem of plants. This is what only appears confuſedly in his writings; for, he employs himſelf rather in giving the ſentiments of others than in advancing reaſons of his own.

8. Empedocles thought that whatever grew, drew its origin from ſeed, which he compares to eggs in this reſpect; that it originally contains in it a nutritive aliment, which it immediately communicates to the root. And Ariſtotle, reaſoning on this ſentiment of Empedocles, ſays, "that in plants the two ſexes are united," which makes them capable of propagating themſelves; but inſtead of a fœtus, they produce ſeed, which is the fruit of their generative faculty. And on this account Empedocles called plants oviparous; for the ſeed, or "egg," ſaid he, "is the fruit of the generative faculty, one part of which ſerves to form the plant, and the other to nouriſh the germ and root; in animals of different ſexes, we ſee that nature, when they would procreate, impels them to unite, and like plants to become one; that from this combination of two, there may ſpring up another animal."

9. As to the manner in which fruits were impregnated, the ancients were not ignorant, that it was by means of the prolific duſt contained in the flower of the male; and they carried the accuracy of their obſervations ſo far as to remark, that the fruits of trees never come to maturity, till they have been cheriſhed with that duſt. Upon this, Ariſtotle ſays, "that if one ſhake the duſt of a branch of the male palm over the female, her fruits will quickly ripen; and that when the wind ſheds this duſt of the male upon the female, her fruits ripen apace."

10. Theophraſtus, treating of the ſame ſubject, ſays, "They bring the male to the female palm in order

der to make her produce fruits. The manner in which they proceed is this. When the male is in flower, they ſelect a branch abounding in that downy duſt which reſides in the flower, and ſhake this over the fruit of the female. This operation prevents the fruit from becoming abortive, and brings it ſoon to perfect maturity." "Naturaliſts," ſays Pliny, "admit the diſtinction of ſex not only in trees, but in herbs, and in all plants. Yet this is no where more obſervable," adds he, "than in palms, the females of which never propagate, but when they are fecundated by the duſt of the male." He calls the female palms, deprived of male aſſiſtance, barren widows. He compares the conjunction of theſe plants to that of animals; and ſays, "that to generate fruit, the female needs only the aſperſion of the duſt of the flowers of the male."

CHAP. V.

Of the Chymistry of the Ancients.

1. IF we will be guided by the greateſt number of etymologiſts, there needs no deep reſearch to demonſtrate the antiquity of Chymiſtry. Its name ſeems to declare its origin. It is agreed almoſt by all, that it was firſt cultivated in Egypt, the Country of Cham, of whom it is ſuppoſed to have taken its name Χημεία Chemia, ſive Chamia, the ſcience of Cham. In the 105th pſalm, Egypt is called, "The Land of Cham." According to Bockart, the Coptes ſtill call themſelves Chemi, or Chami; and Plutarch, in his Iſis and Oſiris, ſpeaking of a diſtrict of Egypt, names it Chamia, quaſi Chimia. But without entering here into a philological diſcuſſion, I ſhall content myſelf with conſidering whether the ancients were Chymiſts, and to what degree; and hope to make it appear, that they not

only knew all of that art, which we do, but had ſuch inſight in it, as we have not at preſent.

2. The firſt inſtance that occurs for aſcertaining the antiquity of the ſcience, is of a very remote date. Nobody, I think, will doubt, but Tubal-Cain, and thoſe who with him found out the way of working in braſs and iron, muſt have been able chymiſts. It was impoſſible to work upon theſe metals, without knowing the art of digging them out of the mine, of excavating them, and of refining and ſeparating them from the ore, all which are chymical operations, and muſt have been at firſt invented by thoſe who excelled in the art, however afterwards they might be put in practice by the meaneſt artizans. Thoſe who are engaged in the working of copper mines, for inſtance, and know that the metal muſt paſs above a dozen times through the fire, before it can acquire its proper colour and ductility, will eaſily enter into this ſentiment. It is needleſs to bring together here all the paſſages of Heathen Hiſtorians, which ſpeak of Vulcan in the ſame manner as the ſacred Author does of Tubal-Cain, and to ſhew the reader from the reſemblance, and as it were identity of names, that all of them relate to one and the ſame perſon. It is enough to obſerve that thoſe authors repreſent Vulcan as ſkilled in operating upon iron, copper, gold, ſilver, and all the other bodies capable of ſuſtaining the action of fire.

3. I likewiſe paſs over whatever carries in it the air of fable: ſuch as the ſtory of the Golden Fleece; the Golden Apples that grew in the gardens of the Heſperides, the reports of Manethon and Joſephus with relation to Seth's pillars, and come to facts real and eſtabliſhed: and for the ſake of Chronology, I ſhall ſtill adhere to the ſacred Text, in contemplating an action of Moſes, who having broken the Golden Calf, reduced it into powder to be mingled with water, and given to the Iſralites to drink; in one word, rendered the gold potable: an operation ſo difficult, that it is entirely impracticable to moſt of the Chymiſts of our days, and owned by Boerhaave to be of ſo exalted a kind

a kind, that it is unknown at preſent to the moſt ſkilful. Yet it muſt be admitted, that it had been looked upon by ſome able Chymiſts, as practicable, who at the ſame time acknowledged it to be a moſt remarkable proof of Moſes' eminent ſkill in all the wiſdom of Egypt. For how, without the aid of Chymiſtry, could Moſes have diſſolved the golden calf, and that too without applying corroſives, which would have poiſoned all who had afterwards drank of the waters? Yet this was to be done, and in a ſhort time too, though there be but one way of doing it. Frederic the Third, King of Denmark, curious to put this operation in practice, engaged ſome able chymiſts to attempt it. After many trials they at laſt ſucceeded, but it was in following the method of Moſes by firſt reducing the gold into ſmall parts by means of fire, and then pounding in a mortar (along with water,) till it was ſo far diſſolved as to become potable. This fact cannot be called in queſtion, nor has it any thing ſupernatural in it. We know that Moſes was inſtructed in all the learning of the Egyptians, among whom the ſciences were cultivated with all manner of ſucceſs, and from whom the moſt eminent philoſophers of Greece derived their knowledge.

4. How they formed that cement, which they applied in rearing theſe monuments that ſtill ſubſiſt, remains a ſecret to us; though it be paſt all doubt, that they prepared it in a chymical way, ſo hidden, however to us, that we daily lament the loſs of it. The numberleſs mummies which ſtill endure, after ſo long a courſe of ages, ought to aſcertain to the Egyptians the glory of having carried chymiſtry to a degree of perfection attained but by few. In their mummies alone, there is ſuch a ſeries of operations, that ſome of them ſtill remain unknown, notwithſtanding all the attempts of ſome of the ableſt moderns to recover them. The art of embalming bodies, and preſerving them for many ages, is abſolutely loſt; and never could have been carried ſo far as it was by the Egyptians, without the greateſt ſkill in Chymiſtry. All the eſſays to reſtore this art, have proved ineffectual, nor have the

re-iterated

re-iterated analyſes made of mummies, to diſcover the ingredients of which they were compoſed, had any better ſucceſs. Some moderns have attempted, by certain preparations, to preſerve dead bodies entire, but to no purpoſe. The mummies of Lewis de Bils, who was regarded as eminent in that way, are aheady in a ſtate of corruption. There were alſo, in thoſe mummies of Egypt, many things beſides, which fall within the verge of Chymiſtry: ſuch as their gilding, ſo very freſh, as if it were but of fifty years ſtanding; and their ſtained ſilk, ſo vivid in its colours, though after a ſeries of thirty ages. In the Muſeum at London, there is a mummy covered all over with fillets of granated glaſs, various in colour, which ſhews that this people at that time, underſtood not only the making of glaſs, but could paint it to their liking. It may be remarked here, that the ornaments of glaſs with which that mummy is bedecked, are tinged with the ſame colours, and ſet off in the ſame taſte, as the dyes in which almoſt all other mummies are painted; ſo that it is probable, this kind of ornaments being very expenſive, was reſerved for perſonages of the firſt rank only, whilſt others, who could not afford this, contented themſelves with an imitation of it in painting.

5. It would be eaſy to make a more extenſive enumeration of the particulars of the chymical proceſs, which concurred to the compoſition of a mummy; but I proceed to take notice of their manner of painting upon linen, which, if I miſtake not, is ſtill a ſecret to us. After having drawn the outlines of their deſign upon the piece of linen, they filled each compartment of it with different ſorts of gums, prepared to abſorb the various colours; ſo that none of them could be diſtinguiſhed from the whiteneſs of the cloth. Then they dipt it for a moment in a caldron full of boiling liquor, proper for the purpoſe: and drew it thence painted in all the colours they intended. And what was remarkable, the colours neither decayed by time, nor moved in the waſhing: the cauſtic, impregnated the liquor wherein it was dipt, having penetrated and fixed every colour intimately through the whole contexture of the cloth.

cloth. This ſingle inſtance is ſufficient to give us a very high conception of the progreſs that Chymiſtry had made among the Egyptians, though their hiſtory affords a thouſand others of the kind, not to be wondered at among a people ſo very active and induſtrious, where even the lame, the blind, and the maimed, were in conſtant employment, and ſo little ſubject to envy, that they inſcribed their diſcoveries in the arts and ſciences, upon pillars reared in holy places, in order to omit nothing that might contribute to the public utility. The Emperor Adrian atteſts this firſt part of their character, in a letter written to the Conſul Servianus, upon preſenting him with three very curious cups of glaſs, which like a pidgeon's neck reflected, on whatever ſide they were viewed, a variety of colours, repreſenting thoſe of the precious ſtone called Obſidianum, which ſome commentators have imagined to be the Cats-eye, and others the Opal.

6. This art of imitating precious ſtones, was not peculiar to the Egyptians; the Greeks, who indeed derived their knowledge from thoſe great maſters, were alſo very ſkilful in this branch of Chymiſtry. They could give to a compoſition of cryſtal, all the different tints of any precious ſtone they wanted to imitate. Pliny, Theophraſtus, and many others, give inſtances of this; but they moſt remarkably excelled in an exact imitation of the ruby, the hyacinth, the emerald, and the ſapphire.

7. Chymiſtry being a principal branch of medicine, it will not be amiſs to mention ſome particulars, wherein the Egyptians have contributed to the perfection of that ſcience. I ſet aſide the hiſtory of Eſculapius, who was inſtructed by Mercury or Hermes. Their pharmacy depended much upon Chymiſtry; witneſs their manner of extracting oil, and preparing opium, for alleviating of acute pains, or relieving the mind from melancholy thoughts. Homer ſeems to have had this laſt in view, when he introduces Helen as miniſtering to Telemachus a medical preparation of this kind. They alſo made a compoſition or preparation of clay

or

or fuller's earth, adapted to the relief of many diſorders, particularly to render the fleſhy parts dry, and thence to cure the dropſy and the hemorrhoides. They knew all the different ways of compoſing ſalts, nitre, and alum, ſal cyrenaic or ammoniac, ſo called from being found in the environs of the Temple of Jupiter Ammon. They made uſe of the litharge of ſilver, the ruſt of iron, and calcined alum, in the cure of ulcers, cuts, boils, defluxions of the eyes, pains of the head, &c. and of pitch againſt the bite of ſerpents. They ſucceſsfully applied cauſtics. They knew every different way of preparing plants, or herbs, or grain, whether for medicine or beverage. Beer in particular, had its origin among them. Their unguents were of the higheſt eſtimation, and moſt laſting; and their uſing remedies, taken from metallic ſubſtances, is ſo manifeſt in the writings of Pliny and Dioſcorides, that it would be needleſs to enter upon them here. Dioſcorides often makes mention of their metallic preparations, ſuch as burnt lead, ceruſe, verdigreaſe, and burnt antimony; all which they made uſe of in their plaiſters, and other external applications. It ſhould be obſerved here, that I have had nothing in view, but the pharmacy of the Egyptians; otherwiſe I might have made mention of the Theriac, that famous compoſition of Andromachus the phyſician of Nero, which has at all times been in high eſtimation, and is now in as much repute as ever. What little I have advanced reſpecting the medicinal chymiſtry of the ancients, muſt ſuffice upon this occaſion; the Greeks and Romans preſenting a field too vaſt to be comprized in a tract of this kind. Hippocrates eſpecially, the cotemporary and friend of Democritus, was remarkably aſſiduous in the cultivation of Chymiſtry. A learned man has compoſed an entire book on the extenſive comprehenſion he had of it, whereby it appears, that he not only underſtood the general principles of it, but was an adept in many of its moſt uſeful parts. Paſſages are quoted from Plato, that are received as axioms in Chymiſtry. Galen knew that the energy of the fire might be applied to many uſeful purpoſes, and that by the inſtrumentality of it, many ſecrets in nature were to be diſcovered, which

otherwiſe

otherwiſe muſt for ever be hid; and he gives many inſtances of this in ſeveral places of his works. Dioſcorides hath tranſmitted to us many of the mineral operations of the ancients, and in particular that of extracting quickſilver from cinnabar, which is in effect an exact deſcription of diſtillation.

8. The merit of the ancients in having arrived at the knowledge of this important operation of Chymiſtry, has been much called in queſtion; which makes it requiſite to give particular attention to this paſſage of Dioſcorides, which not only indicates the practice of diſtillation among the ancients, but ſhews that this branch of chymiſtry derived from the Greek language the name of its principal inſtrument, the Alembic. The word ἄμβιξ ambix, according to Athenæus, meant the cover of a pot, or any veſſel wherein liquids were ſet a boiling; and the Arabs adopted this word in applying it to the ſame ſubject, only adding the ſyllable al to the beginning of it, a ſyllable that enters into the beginning of moſt of their words, whence ſprung the word Alembic. Pliny alſo gives the ſame explanation as Dioſcorides does, of the manner of extracting quickſilver from cinnabar by diſtillation. And Seneca deſcribes an inſtrument exactly reſembling the Alembic, and which ſeems to have been applied to the ſame uſe. But there are other indications beſides, full as ſure as thoſe, that diſtillation had place among the ancients. For without reckoning that brewing of beer implies the uſe of a ſtill, we find Ariſtotle obſerves, that oil could be extracted from ſea ſalt; which never could be done without diſtillation. Hippocrates deſcribes the proceſs of that operation; talks of vapours ariſing from the boiling fluid, which meeting with reſiſtance ſtop and condenſe, till they fall in drops from the body to which before they clung in the form of vapours. And Zoſimus of Panopolis, not only deſires his ſtudents to furniſh themſelves with Alembics, but gives them directions how to uſe them, and places before their eyes draughts of ſuch as beſt deſerve to be employed in practice.

9. To proceed to other particulars of general chymiſtry;

miſtry; the ancients among other things were acquainted with lixivial ſalt, or ſal alcali, one of the prime principles of bodies. Sal alcali means properly the ſalt extracted by fire from the Egyptian plant kali, but as it is extracted alſo from other vegetables, though in leſs quantity, chymiſts extend the name of all thoſe ſalts, which like that of this plant, attract and imbibe acids, and by their contexture penetrate into them, and cloſely unite with them. Theſe ſalts are termed promiſcuouſly lixivial ſalt, ſal alcali, rock ſalt, &c. It is of them Ariſtotle ſpeaks, when he ſays that in Umbria the burnt aſhes of ruſhes and reeds, boiled in water, yield a great quantity of ſalt. Theophraſtus obſerves the ſame of Umbria. Varro relates, that ſome who dwell on the borders of the Rhine, having neither ſea nor pit ſalt, ſupply themſelves with it by means of the ſaline cinders of burnt plants. Pliny aſſures us, that aſhes are impregnated with ſalts, and ſpeaks in particular of the nitrous aſhes of burnt oak; adding, that theſe ſalts are uſed in medicine, and that a doſe of lixivial aſhes is an excellent remedy. In ſhort, Hippocrates, Celſus, Dioſcorides, and eſpecially Galen, often recommended the medical uſe of ſal alcali; and their writings are filled with paſſages, which ſhew that they all underſtood it. To the mixture of acids and alcali it was, that Plato aſcribed fermentation; and Solomon ſeems to have known this effect of them when he brings as an inſtance of it, vinegar, and the nitre of Egypt.

10. Another convincing proof of the ability of the Ancients in Chymiſtry, is the experiment with which Cleopatra entertained Marc Antony, in diſſolving before him, in a kind of vinegar, a pearl of very great value. I ſay, in a kind of vinegar; for at preſent we know not of any that can produce this effect; but as the fact is ſo well atteſted, we muſt thence conclude that the queen added ſomething to the vinegar, omitted by the hiſtorian: and that Phacas, who was her phyſician, aſſiſted her at that time with his aid, in enabling her thus to gain the wager which ſhe had laid with Marc Antony, that ſhe would exceed him in the coſtlineſs of her entertainment. But even the queen herſelf was

a great

a great adept in this art, as appears from ſome of her performances, ſtill preſerved in the Libraries of Paris, Venice, and the Vatican. And Pliny informs us of the Emperor Caius, that by means of fire extracted ſome gold from a quantity of orpiment.

11. The method of rendering glaſs ductile, is a ſecret ſtill uncomprehended by us, though formerly well known to the Ancients. The authors who lived at the very time when this was done, ſpeak of it ſo circumſtantially, that it is impoſſible to doubt it. They are Pliny, Petronius, Ibn Abd Alhokin, John of Saliſbury, Iſidorus, and others. Pliny ſpeaks only of the flexibility of glaſs, which he ſays was found out in the time of Tiberius; but that the Emperor fearing leſt gold and ſilver, thoſe moſt precious metals, ſhould thereby fall in their value, ſo as to become contemptible, ordered the reſidence, workhouſe and tools of the ingenious artizan to be deſtroyed, and thus cut off this art in its riſe. Petronius goes farther, and ſays, that in the time of Tiberius there was an artificer, who made veſſels of glaſs, which were in their compoſition and fabric as ſtrong and durable as ſilver or gold; and that being introduced into the preſence of the Emperor, he preſented him with a vaſe of this kind, ſuch as he thought worthy of his acceptance; and that meeting with the praiſe his invention deſerved, and finding his preſent ſo favourably received, he, to increaſe the admiration of the ſpectators, and further to ingratiate himſelf with the Emperor, laid hold on the vaſe, throwing it with ſuch violence on the floor, that had it been of braſs, it muſt have been injured by the blow; that he took it up again whole, but dimpled a little, which he immediately repaired with a hammer he took from his breaſt: and that while he was in expectation of ſome very ample reward in recompenſe of his ingenuity, the Emperor aſked him whether any body elſe was acquainted with this method of preparing glaſs, and being aſſured that no other was, immediately ordered his head to be cut off; leſt gold and ſilver, added he, ſhould become as baſe as the dirt we tread upon. In theſe two teſtimonies, we ſee how this diſcovery came

ſo

ſo ſoon to be loſt. If whatever is new, be with ſo much difficulty eſtabliſhed, notwithſtanding every encouragement, how was it poſſible for this to endure, when ſo ſudenly ſurpriſed by inevitable fate. Dion Caſſius, on this head, confirms the atteſtations of Pliny and Petronious. John of Saliſbury and Iſidorus, relate this ſame fact in the ſame way.

As to the Arabian Ibn Abd Alhokin, he ſpeaks of malleable glaſs as a thing known in the flouriſhing times of Egypt; but he himſelf is ſo unknown, that I know not how to reſt on his authority. Greaves, who makes mention of him as a celebrated chronologiſt among the Arabians, cites from him the paſſage, wherein it is ſaid, that Saurid, king of Egypt, who built three pyramids, depoſited in them, among other precious things, malleable glaſs, &c. I ought not to leave this ſubject, without mentioning the attempts made by the moderns to render glaſs pliant and malleable. There is a chymical compoſition, well-known, formed of ſilver diſſolved in acid ſpirits, which is called cornu lunæ, a tranſparent body, eaſily put into fuſion, and very like horn or glaſs, and which will bear the hammer. Borrichius makes mention of an experiment of his own, tending to prove the poſſibility of rendering glaſs ductile; it conſiſted in compoſing a pliant and malleable ſalt, for the making of which he gives the receipt; concluding from thence, that as glaſs for the moſt part is only a mixture of ſalt and ſand, and as the ſalt may be rendered ductile, it ought not to be looked upon as impoſſible that glaſs may be made malleable. And he imagines, that the Roman artificer, ſpoken of by Pliny and Petronius, may have aſſumed antimony as the principal ingredient of his glaſs. Beſides we may obſerve, that nature hath formed many bodies, having an analogy to that of glaſs, ſuch as the horns of animals, amber, the Ruſſian talc, and ſeveral others, all which are tranſparent, and at the ſame time pliant and malleable. Deſcartes alſo takes notice, that ſalt may be rendered malleable, and for that very reaſon intimates, that it is poſſible to ſucceed in giving the ſame property to glaſs. And Morhoff aſſures us, that the celebrated Boyle was alſo of this opinion. In ſpeaking

of

of glaſs I may add, that the art of painting, ſo far as it depends upon chymiſtry, was carried formerly to a much higher degree of perfection, than it is at preſent. Of this we have ſtriking inſtances in the windows of ſome ancient churches, where paintings preſent themſelves in the moſt vivid colours, without detracting from the tranſparency of the glaſs; and which, as Boerhaave obſerves, are hardly to be imitated at preſent, we having loſt the ſecret to a degree, that there are ſcarce any hopes of ever recovering it. The enamelling and moſaic works of the ancients yield the ſame kind of evidence of their ſkill in chymiſtry; of the former of which many inſtances occur in the works of Pliny and others.

12. Having ſpoken of the chymiſtry of the Egyptians, and of that of the Greeks and Romans, who derived their inſtructions from thoſe firſt maſters; it would not be pardonable to omit mentioning Democritus, the parent of experimental philoſophy. This great man, for the ſake of acquiring wiſdom, travelled into Egypt, and made his abode with the prieſts of the country, as we are informed by Diogenes Laertius, Strabo, Clemens Alexandrinus, Euſebius, and Syneſius. Vitruvius tells us, that he wrote many books on natural philoſophy, and was wont to put his ſeal upon thoſe experiments which he had tried himſelf. Diogenes Laertius ſays the ſame. Petronius affirms, that he extracted the juice of every ſimple, and was ſo wholly taken up in experiments, that there was not a quality belonging to the mineral or vegetable kingdoms that eſcaped his notice; and Seneca aſſerts, that he was the inventor of reverberating furnaces, the firſt who gave a ſoftneſs to ivory, and imitated nature in her production of precious ſtones, particularly the emerald.

13. I ſhall finiſh this chapter with an aſſertion, that perhaps will ſeem paradoxical; that the ancients knew the uſe of gunpowder. Virgil and his commentator Servius, Hyginus, Euſtathius, La Cerda, Valerius Flaccus, and many other authors ſpeak in ſuch a manner of Salmoneus's attempts to imitate thunder, as

ſuggeſt

ſuggeſt to us that this prince uſed for that purpoſe a compoſition of the nature of gunpowder. Euſtathius in particular ſpeaks of him on this occaſion, as being ſo expert in mechanics, that he formed machines which imitated the noiſe of thunder: and the writers of fable, whoſe ſurpriſe in this reſpect may be compared to that of the Mexicans when they firſt beheld the fire arms of the Spaniards, give out, that Jupiter, incenſed at the audacity of this prince, ſlew him with lightning as he was employing himſelf in launching his thunder. But it is much more natural to ſuppoſe, that this unfortunate prince, the inventor of gunpowder, gave riſe to theſe fables, by having accidentally fallen a victim to his own experiments. Dion and Joannes Antiochenus report of Caligula, that this Emperor imitated thunder and lightning by means of certain machines, which at the ſame time emitted ſtones. Themiſtius informs us, that the Brachmans encountered one another with thunder and lightning, which they had the art of launching from on high at a conſiderable diſtance. Agathias, the hiſtorian, reports of Anthemius Tralienſis, that having fallen out with his neighbour Zeno the rhetorician, he ſet fire to his houſe with thunder and lightning. Philoſtratus, ſpeaking of the Indian ſages, ſays, that when they were attacked by their enemies, they did not leave their walls to fight them, but put them to flight by thunder and lightning. And in another place he relates, that Hercules and Bacchus attempting to aſſail them in a fort where they were entrenched, were ſo roughly received by reiterated ſtrokes of thunder and lightning, launched upon them from on high by the beſieged, that they were obliged to retire, leaving behind them an everlaſting monument of the raſhneſs of their enterpriſe. It appears from all theſe paſſages, that the effects aſcribed to theſe engines of war, eſpecially thoſe of Caligula, Anthemius, and the Indians, could be only brought about by gunpowder. And what is ſtill more, we find in Julius Africanus a receipt for a compoſition to be thrown upon an enemy, which very nearly reſembles that of powder. But what places this beyond all doubt, is a clear and poſitive paſ-

ſage

ſage of an author called Marcus Græcus, whoſe work in manuſcript is in the royal library at Paris, entitled, Liber Ignium. Doctor Mead had the ſame alſo in manuſcript. The author deſcribes ſeveral ways of encountering an enemy, by launching fire upon him; and among others gives the following. Mix together one pound of live ſulphur, two of charcoal of willow, and ſix of ſaltpetre; reducing them to a very fine powder in a marble mortar. He adds, that a certain quantity of this is to be put into a long, narrow, and well compacted cover, and ſo diſcharged into the air. Here we have the deſcription of a rocket. The cover with which thunder is imitated, he repreſents as ſhort, thick, but half-filled, and ſtrongly bound with packthread; which is exactly the form of a cracker. He then treats of different methods of preparing the match, and how one ſquib may ſet fire to another in the air, by having it encloſed within it. In ſhort, he ſpeaks as clearly of the compoſition and effects of gunpowder, as any body in our times could do. I own, I have not yet been able preciſely to determine when this author lived, but probably it was before the time of the Arabian phyſician Meſue, who ſpeaks of him, and who flouriſhed in the beginning of the 9th century. Nay, there is reaſon to believe, that he is the ſame of whom Galen ſpeaks. We ſee alſo by two paſſages, one of Ariſtotle, the other of Pliny, that the art of making ſteel, and of tempering it, was known even in their time.

14. It has been ſometimes objected to the facts I produce, that had the ſtate of things been really ſo, their own utility would have preſerved them from the outrages of time; our preſent ignorance therefore is alledged as of ſufficient force, to invalidate whatever has been reported of the acquiſitions of former times. But how frivolous this objection is appears not only from the cauſe aſſigned of our having loſt the ſecret of rendering glaſs malleable, but alſo from thoſe monuments which ſtill remain, and are daily before our eyes, of the ſuperiority of the ancients in many parts of Chymiſtry: ſuch as the Egyptian mummies, the

painting

painting on glaſs, the perpetual lamps, &c. not to mention, that there are now many ſecrets practiſed in different nations, and unknown in others, ſuch as the Ruſſian way of preparing leather, that of the Turks in tempering ſteel, that of the Chineſe in making porcelain, the lacquer of the Japaneſe, and the dye of the Gobelins.

CHAP. VI.

Of Sensible Qualities.

1. THERE is no part of philoſophy which has made leſs progreſs among the vulgar, than that which, treating of ſenſible qualities, diſmiſſes them entirely from body, to make them reſide in the mind. The moſt eminent philoſophers of antiquity have acknowledged this truth; it ſprung naturally from their principles, and they deduce the ſame conſequences from it. Democritus, Socrates, Ariſtippus, Plato, Epicurus, and Lucretius, have clearly affirmed, that cold and heat, odours and colours, were no other than ſenſations, excited in our minds, by the different operations of the bodies ſurrounding us, and acting on our ſenſes. And it is eaſy to ſhew, that Ariſtotle himſelf was of this opinion, that ſenſible qualities exiſt in the mind; though by the obſcure manner in which he opens himſelf, he hath given occaſion to believe that he thought otherwiſe. There are only the ſchoolmen, who have poſitively affirmed, that ſenſible qualities exiſt in bodies as in minds; that there is in luminous bodies, for example, the very ſame thing that is in us when we view light. And as the philoſophy of the ſchools had for ſome ages taken poſſeſſion of men's minds, when Deſcartes, and after him Mallebranche, aroſe

aroſe in oppoſition to the common prejudices, taking pains to draw the herd of philoſophers out of the groſs errors wherein they found them involved; it was not perceived, that in this they did nothing but renew the very ſame truths, which had been taught by Democritus, Plato, Ariſtippus, and Sextus Empiricus, ſupporting them likewiſe by the very ſame arguments, though ſometimes farther extended. Hence all the honour has been aſcribed to theſe moderns, as if the error they attacked had been that of all ages; nobody deſigning to ſearch any deeper, whether in reality, it was ſo or not. For had they given any attention to what the ancients had advanced, or conſulted their writings, they would ſoon have found that ſome of them, not only ſtripped body of every power of exciting opinions in us, but even ſometimes called in queſtion its very exiſtence. Yet this indolence in aſcertaining the origin of our improvements, was not entirely univerſal. Gaſſendi had publiſhed a tract upon ſenſible qualities, and given alſo an abridgment of the Pyrrhonic philoſophy reſpecting this ſubject, before ever Deſcartes attempted it; ſo that even among the moderns themſelves, Deſcartes is not the firſt who clearly diſtinguiſhed between the properties of ſpirit and body. And as to the ancients, a brief narrative of what Deſcartes and Mallebranche have ſaid, compared with what thoſe ancients taught, will quickly put the reader in a condition of deciding to whom that diſcovery ought to be attributed.

2. Deſcartes begins with remarking, that every one is accuſtomed from his infancy, to look upon whatever he perceives by his ſenſes as exiſting out of his mind; and having an entire reſemblance to the perceptions which he finds there. Obſerving the colour of any object, for inſtance, we think we ſee ſomething without ourſelves, and reſiding in the objects, exactly reſembling our idea of it; and, we acquire ſuch a habit of judging in this manner, that we never entertain any doubt. This is the caſe of all our ſenſations; we ſeldom imagine that they exiſt only in the mind, but rather in our hand, or foot, or ſome other part of our

body

body. There is nothing however more certain, than that the pain which we feel in our foot, is nothing but what the mind perceives as there; in the ſame manner as the light we ſee as it were in the ſun, is an idea raiſed by it in our minds. In the ſame manner we ſay, we perceive colours, or diſcern odours in objects; when theſe ſenſations ariſe in us from ſomething or other in thoſe objects. Such are the miſconceptions of our infant ſtate, from which we can hardly reſcue ourſelves even in advanced life.

3. Mallebranche ſeized this idea of Deſcartes, and more fully opened it. In his celebrated work, the reſearch into truth, he begins with diſcovering that the ſource of our errors is in the abuſe of our liberty, and the precipitation with which we form judgments; inſomuch, that our ſenſes could not impoſe on us, were it not for our raſhneſs. For example, when we ſee light, it is certain we do ſo; when we feel heat, there is no miſtake in imagining we do; but we deceive ourſelves when we fancy, that the heat and odours we perceive are external to the mind that feels them. He then combats the errors ariſing from our way of judging; and having ſtripped the body of its ſenſible qualities, inſtructs us how mind and body co-operate to produce our ſenſations, and how we accompany them with falſe judgments. He blames thoſe who always judge of objects by the ſenſations they excite, and by an appeal to their own feelings; for the feelings of all men being different, though the things themſelves continue the ſame, they muſt judge variouſly as they are affected, but ought not to aſcribe the diverſity of affections to the objects themſelves.

4. Were we to bring into review all the ancients have taught on this ſubject, we ſhould be ſurpriſed at the clearneſs with which they have explained themſelves, and at a loſs to account how opinions came to be taken for new, which had been already illuſtrated in their writings, with ſuch force and preciſion. It cannot ſo much as be ſaid, that the moderns have given a new turn to theſe opinions; for they not only reaſon upon

upon the ſame principles, but employ the very ſame compariſons in proof of them.

5. Democritus was the firſt who diſarrayed body of its ſenſible qualities. That great man, who admitted only of atoms and ſpace as the principles of things, differed from all who had preceded him in that opinion, in that he affirmed, atoms were void of qualities; and in this, he was followed by Epicurus. He derived qualities from the different order and diſpoſition of the atoms among themſelves, as well as from their diverſity of figure; which, according to him, was the cauſe of all the various changes and modifications in nature; ſome of them being round, others angular, ſome ſtraight, ſome pointed, ſome crooked, &c. "Thus the firſt elements of things having in them neither whiteneſs nor blackneſs, ſweetneſs nor bitterneſs, heat nor cold, nor any other quality; it follows, that colour, for example, exiſts only in our perception of it; as alſo, that bitterneſs and ſweetneſs, which exiſt only in being perceived, are the conſequences of the different manners in which we ourſelves are affected by the bodies ſurrounding us, there being nothing in its own nature yellow, or white, or red; ſweet, or bitter."

6. Sextus Empiricus, explaining the doctrine of Democritus, ſays, "that ſenſible qualities," according to that philoſopher, "have nothing of reality but in the opinion of thoſe who are differently affected by them, according to the different diſpoſitions of their organs; and that from this difference of diſpoſition ariſe the perceptions of ſweet and bitter, heat and cold; and alſo, that we do not deceive ourſelves in affirming that we feel ſuch impreſſions; but in concluding that exterior objects, muſt have in them ſomething analogous to our feelings."

7. Protagoras, the diſciple of Democritus, ſays, "that in man is contained the rule or meaſure of every thing; that the whole exiſtence of external things conſiſts in the impreſſion we perceive in ourſelves; in-

ſomuch that what is imperceptible, has no exiſtence." He alſo carried farther, than ever Democrius did, the conſequences of his ſyſtem; for admitting, with his maſter, the perpetual mutability of matter, which occaſioned a conſtant change in things; he then added, that whatſoever we ſee, apprehend or touch, are juſt as they appear; and that the only true rule or criterion of things, was in the perception men had of them. I leave the reader to judge, whether Protagoras's manner of thinking might not have tranſmitted to Berkley the idea of a ſyſtem, which he with ſo much ſubtilty hath maintained; "that there is nothing in external objects, but what the ſenſible qualities exiſting in our minds induce us to imagine, and of courſe that they have no other manner of exiſtence; there being no other ſubſtratum for them, than the minds by which they are perceived: not as modes or qualities belonging to themſelves, but as objects of perception to whatever is percipient."

8. We ſhould think we were liſtening to the two modern philoſophers, when we hear Ariſtippus exhorting men "to be upon their guard with reſpect to the reports of ſenſe, becauſe it does not always yield juſt information; for we do not perceive exterior objects as they are in themſelves, but only as they affect us. We know not of what colour or ſmell they may be, theſe being only affections in ourſelves. It is not the objects themſelves that we are enabled to comprehend, but are confined to judge of them only by the impreſſions they make upon us; and the wrong judgments we form of them in this reſpect, is the cauſe of all our errors. Hence, when we perceive a tower which appears round, or an oar which ſeems crooked in the water; we may ſay that our ſenſes intimate ſo and ſo, but ought not to affirm, that the diſtant tower is really round, or the oar in the water crooked; it is enough, in ſuch a caſe, to ſay, that we receive the impreſſion of roundneſs from the tower, and of crookedneſs from the oar; but it is neither neceſſary, nor proper to affirm, that the tower is really round, or the oar broken; for a ſquare tower may appear round at a diſtance,

a diſtance, and a ſtraight ſtick always ſeems crooked in the water."

9. Ariſtippus ſays farther, "there is not in man any faculty that can judge of the truth of things; any farther than that men have given common names to their own apprehenſions. Thus every body talks of whiteneſs and ſweetneſs, but they have no common faculty to which they can with certainty refer impreſſions of this kind. Every one judges by his own apprehenſions, and nobody can affirm that the ſenſation which he feels when he ſees a white object, is the ſame with what his neighbour experiences in regard to the ſame object; and becauſe the powers of apprehenſion are not entirely the ſame in all, it is temerity in us to aſſert, that what appears in ſuch or ſuch a manner to one, muſt needs do ſo to every body elſe: for one may be ſo conſtituted, that the objects which offer themſelves to his eye may appear white, while to thoſe of a man differently conſtituted they ſeem yellow; as is manifeſt in thoſe who have the jaundice, or any other natural diverſity of diſcernment, and who by reaſon of the different contexture of their organs, are incapable of receiving from the ſame things, the ſame impreſſions that others do. Thus he, who has large eyes, will ſee objects in a different magnitude from him whoſe eyes are little; and he who hath blue eyes, diſcerns them under different colours from him who hath grey."

10. Plato, following Protagoras, clearly diſtinguiſhes between ſenſible qualities, and the objects which cauſe them. He obſerves, that the ſame wind appears cold to one, and hot to another; to one ſoft, and to another rough: but that we ought not hence to conclude, that the wind is in itſelf hot and cold at the ſame time; but to ſay with Protagoras, that he who is hot, feels it hot, &c.

11. I come now to Epicurus, whoſe doctrine is explained with the greateſt exactneſs by Plutarch, but above all by Diogenes Laertius. This philoſopher, admitting

mitting the principles of Democritus, hath thence deduced the moſt natural conſequences: "that atoms are all of the ſame nature, and differ only in figure, magnitude, and weight, and that in the conſtitution of every thing, they bear ſome affinity to its principal properties, ſuch as roundneſs, bulk, &c. For colour, ſays he, cold and heat, and the other ſenſible qualities, are not inherent in the atoms, but the reſult of their aſſemblage: and the difference between them flows from the diverſity of their ſize, figure, and arrangement; inſomuch, that any number of atoms in one diſpoſition, creates one ſort of ſenſation; and in another, another: but their own primary nature remains always the ſame, becauſe, being ſolid and uncompounded, no parts tranſpire, otherwiſe nature would not be in the main fixed and ſtable; and it is from the permanency of the properties eſſential to atoms of matter, that the different ſenſations ariſe, which the ſame objects produce in animals of different ſpecies, and in men of different conſtitutions; for each have in the organs of ſight, hearing, and the other ſenſes, an innumerable multitude of pores differently ſized and ſituated: theſe are variouſly adapted and proportioned for the reception of the ſmall corpuſcles, which eaſily inſinuate themſelves into ſome, and with difficulty into others, (according to the analogy between them and the pores, and the variety of contexture in the parts,) and of courſe muſt produce different impreſſions."

12. So that the ſenſes do not deceive us, for they are not judges of the nature of things; but ſerve only to inform us of the connexion and relation between the bodies ſurrounding us and our own, in ſubſerviency to our happineſs in this life: whence it is obvious, that our ſenſations are always true, though the judgments we many times form reſpecting their objects are ſometimes falſe: as muſt always be the caſe, whenever we alter thoſe objects themſelves which are the exterior cauſes of our ſenſations, by either adding ſomething foreign to them, or retrenching from them, what is properly their own. "If any think they are

impoſed upon by the different appearances which reſult from one and the ſame object; as, for example, when a body ſeen at a diſtance appears of one colour, and when nigh of another; it is themſelves who are guilty of the deception, in imagining that the one appearance is true; and the other illuſory: for in that, they form a falſe judgment, not rightly conſidering the nature of things; whereas, they ought, on the contrary, to have concluded that both colours were true, though different, occaſioned by the change of ſituations in which they were viewed, which produced two ſenſations not the ſame, but equally true. Whence it alſo happens, that it is not the ſound in the braſs that is beaten, or the voice itſelf of a perſon who ſings, that are the objects of our perception, but only that which acts upon our ear; for one and the ſame thing cannot be in two different places at once. And as no man ſays, that his judgment is impoſed upon, becauſe a ſound ſtrikes him more feebly at a diſtance, than when he hath approached the place whence it comes; neither can we ſay, that our ſight illudes us, when at a diſtance, a tower appears ſmall and round, which upon our approach to it, would be found large and ſquare: for the repreſentative ſize of the object is in exact proportion to that of the angle formed by it in the eye, which varies according to the difference of the diſtance. In a word, the uſe of the ſenſes is to repreſent objects to us under certain appearances; but not at all to judge of what they are in themſelves: and hence our ſenſations are always true; error being only the reſult of our judgment.

13. I have been the more large on this ſubject, becauſe it is one of the moſt proper to prove the truth of my propoſition, that the moderns have often enriched themſelves with the ſpoils of the ancients, without having done them the honour of any acknowledgement. With reaſon have we praiſed Deſcartes and Mallebranche, for having treated this matter with ſo much penetration. But they have ſcarcely advanced any thing but what had been ſaid before by thoſe ancient philoſophers, whom I have been quoting.

CHAP.

CHAP. VII.

Of Animated Nature.

1. THE Ancients, ſays Mr. Buffon, underſtood much better, and made a greater progreſs in the natural hiſtory of animals and minerals, than we have done. They abounded more in real obſervations; and we ought to have made much better advantage of their illuſtrations and remarks. Yet he does not often ſupport his ſentiment by their authority; hence one might be led to believe, that he did not himſelf perceive the analogy which every where reigns between his ſyſtem, and that of the Ancients. Let the reader himſelf determine on it, upon peruſing what I have to offer. Mean while it is but right to obſerve, that it cannot be concluded from Mr. Buffon's not ſupporting himſelf by the authority of the Ancients, that he was not acquainted with their ſentiments, and ſtill much leſs, that having ſtudied them, he did not diſcern the conformity between theirs and his own. And I make this obſervation with the leſs repugnance, becauſe I do not hereby detract from the reputation of that able writer, who will always poſſeſs the merit of having with the greateſt ſagacity apprehended the principles of the Greek philoſophers, and revived their reaſonings, the greateſt part of which had been ravaged by the injuries of time.

2. I cannot but look upon the reſtorer of the ſyſtem of any great man, the frame of which only ſhews itſelf in a few remaining fragments, as upon an able ſculptor, who from the broken buſt of Phidias, or any other famous Ancient, is capable, by the ſtrength of his own genius, and the ſkill he has in his art, exactly to judge by that ſingle piece, of the proportions which ought to take place in every member, ſo as to form and unite them together, in ſo juſt a manner, that his ſtatue ſhall be as perfect as the other. The merit of ſuch a modern

dern artiſt, doubtleſs deſerves great praiſe; but the glory of the ancient one will ſtill be ſuperior, becauſe the idea of the proportions of the adjuſted members, was taken from that of thoſe in the broken buſt. It is eaſy to apply this compariſon to modern philoſophers, of whom the moſt eminent, ſo far from ſeeking to avoid the charge of having borrowed their opinions from the Ancients, have often been the firſt to own it; of which Deſcartes, and the principal Newtonians, furniſh us with ſtriking examples.

3. Diogenes Laertius, Plutarch, and Ariſtotle inform us, that Anaxagoras thought bodies were compoſed of ſimilar, or homogeneous particles; that thoſe bodies, however admitted a certain quantity of ſmall particles that were heterogeneous, or of another kind; but that to conſtitute any body of a particular ſpecies, it ſufficed that it was compoſed of a great number of ſmall particles, ſimilar and conſtitutive of that ſpecies. Different bodies were maſſes of particles ſimilar among themſelves; diſſimilar however relatively to thoſe of any other body, or to the maſs of ſmall particles, belonging to a different ſpecies. They believed, for example, that blood was formed of many particles, each of which had blood in it; that a bone was formed of many ſmall bones, which from their extreme littleneſs evaded our view. Likewiſe, according to this philoſopher, nothing was properly liable to birth, or to death; generations of every kind, being no other than an aſſemblage of ſmall particles, conſtituent of the kind; and the deſtruction of a body being no other, than the diſunion of many ſmall bodies of the ſame ſort, which always preſerving a natural tendency to re-unite, produce again by their conjunction with other ſimilar particles, other bodies of the ſame ſpecies. Vegetation and nutrition were but means employed by nature for the continuation of beings: thus, the different juices of the earth, being compoſed of a collection of innumerable ſmall particles intermixed, conſtituting the different parts of a tree or flower, take, according to the law of nature, different arrangements; and by the motion originally impreſſed upon them, proceed, till arriving at the

places

places deſtined and proper for them, they collect themſelves, and halt, to form all the different parts of that tree or flower: in the ſame manner as many ſmall imperceptible leaves go to the formation of the leaves we ſee; many little parts of the fruits of different kinds, to the compoſition of thoſe which we eat; and ſo of the reſt. The caſe was the ſame, according to that philoſopher with reſpect to the nutrition of animals. The bread we eat, and the other aliments we take, turn themſelves according to this ſyſtem, into hairs, veins, arteries, nerves, and all the other parts of our bodies; becauſe there are in thoſe aliments, the conſtituent parts of blood, nerves, bones, hair, &c. which uniting with one another, make themſelves by their coalition perceptible, which they were not before, becauſe of their infinite ſmallneſs.

4. Empedocles hath acknowledged the ſame with reſpect to animal nutrition, which he ſays, forms itſelf out of the ſubſtance of aliments proper and accommodated to the animal nature. He alſo taught, that matter had in it a living principle, a ſubtle, active fire, which put all in motion; and which Mr. de Buffon calls, by another name, organized matter, always active; or, animated organic matter. And this matter, according to Empedocles, was diſtributed through the four elements among which it had an uniting force to bind them, and a ſeparating, to put them aſunder, for the ſmall parts either mutually embraced, or repelled one another; whence nothing in reality periſhed, "but every thing was in perpetual viciſſitude." Whence it follows, according to the ſyſtem of Empedocles, as well as that of Anaxagoras, nothing had either life or death properly ſo called, but that the eſſence of things conſiſted in that active principle, whence they aroſe, and into which they all reduced themſelves at laſt. He had alſo a ſentiment reſpecting generation, which Mr. de Buffon hath followed, expreſſing it in the very ſame terms; where he ſays, that the ſeminal juices of the two ſexes contain all the ſmall parts analogous to the body of an animal, and neceſſary to its production.

5. Plotinus,

5. Plotinus, following the idea of Empedocles, and inveſtigating the reaſon of this ſympathy in nature, diſcovered it to proceed from ſuch a harmony and aſſimilation of the parts, as bound them together when they met, or repelled them when they were diſſimilar: he ſays, that it is the variety of theſe aſſimilations that concur to the formation of an animal: and calls that binding or diſſolving force, the magic of the univerſe: and his able interpreter, Marſilius Ficinus, explaining the ſenſe of that paſſage, ſays, that the different parts of every animal, have an attractive virtue in them, by means of which they aſſimilate ſuch parts of the aliment as beſt agree with them.

6. I come now to the ſyſtem of Mr. de Buffon. He thinks with Anaxagoras, that there is in nature a common matter to animals and vegetables, which ſerves for the nutrition and expanſion of all that lives or vegetates; and with Plotinus, that this matter contributes to their nutrition and expanſion, in being aſſimilated to each part of an animal or vegetative body, and entering into their inmoſt pores. This nutritive and productive matter, is univerſally ſpread through all, and compoſed of organic particles, ever active, tending towards organization, and of themſelves, aſſuming a variety of forms, according to their ſituations; ſo that with Anaxagoras, he thinks there is no pre-exiſtent ſeed, involving infinite numbers of the ſame kind, one within another; but an ever active organic matter, always ready ſo to adapt itſelf, as to aſſimilate, and render other things conformable to that wherein it reſides: the ſpecies of animals and vegetables can never therefore exhauſt themſelves; but as long as an individual ſubſiſts, the ſpecies will be renewed. It is as extenſive now, as it was at the beginning, and all will ſubſiſt till they are annihilated by the Creator. It follows from theſe principles, that generation and corruption are only a different aſſociation or disjunction of ſimilar parts, which after the diſſolution of an animal or vegetable body, ſerve to re-produce another of the ſpecies: provided, according to Mr. de Buffon, that thoſe ſmall conſtituent parts meet in a place proper for

the expanſion of themſelves, ſo as to uncloſe what ought thence to reſult for the generation of an animal, or that they paſs through the interior mould of an animal or vegetable, and aſſimilate themſelves to the different parts in intimately adhering to them; and it is in this laſt reſpect only, that any difference ſubſiſts between the opinions of the Ancients laſt mentioned, and the theory of Mr. de Buffon. He thinks, that the ſimilar and organic parts do not become ſpecific, till after they have aſſimilated themſelves to the different parts of the bodies, into whoſe compoſition they enter; whereas Anaxagoras believed them always ſpecific, and did not think that they had need to enter the inſide of the parts in order to aſſimilate.

7. Another principle of Mr. de Buffon, is that when the nutritive matter abounds more than ſufficient for the nouriſhment and expanſion of an animal or vegetable body, it is remitted through all parts of the body, into one or more reſervoirs, in form of a liquor, which is the ſemen of the two ſexes, which mingled together, contributes to the formation of a fœtus, which becomes male or female in proportion as the ſeed of the male or female abounds more or leſs in the organic aſſemblages; and reſembles father or mother, according to the different combinations of the two ſeeds. One finds alſo the origin of this idea, in Pythagoras, Ariſtotle, and Hippocrates.

8. It would be to ſtray from my ſubject, were I to treat of the merit of one or other of theſe ſyſtems. My ſcope will be ſufficiently attained, if I make the analogy of them appear. It ſeems to me, that both of them are the productions of very fine geniuſes; that of Anaxagoras is more intricate, and not ſupported by the exact experiments, which ſuſtain that of Mr. de Buffon; it were to be wiſhed therefore, that the Greek philoſopher had diſcovered the principles traced out by the modern; but the advantage the one had of making uſe of a microſcope, ought not to turn to the diſadvantage of the other; yet hereafter, we ſhall ſee, that the Ancients, in this reſpect, did not long remain behind.

There

There is another ſyſtem, which is no leſs ingenious than this, and of which we find equal traces among the Ancients.

CHAP. VIII.

Nature Active and Animated.

1. AFTER a long courſe of microſcopic obſervations, Mr. Needham hath remarked, that they all contributed to make appear, that animal and vegetative ſubſtances are originally the ſame; that they reciprocally turn into one another, by a very eaſy change; that they decompound themſelves into an infinite number of Zoophytes, which ſeparating, produce all the different ſpecies of common microſcopic animals, which after a certain time become immoveable, ſeparating themſelves again, and producing other zoophytes or animals of an inferior ſpecies; that the ſpermatic animalcules have the ſame property of ſeparating themſelves, and in their decompoſition of producing ſtill ſmaller animals, till at laſt they become ſo very ſmall, that they entirely eſcape notice. The author of theſe obſervations believes, that it is probable beſides, that every animal or vegetable ſubſtance advances as much as it can to its diſſolution, to return by degrees to the principles common to all bodies, and which are of a general nature.

2. The author then inſinuates, that in their decompoſition, bodies ſo ſubtilize themſelves, that the reſiſtance continually diminiſhes, and the active moving force, proportionally augments; that after having paſſed the line of ſpontaneity, the movement diminiſhes quicker or ſlower, till it becomes purely oſcillatory; and of courſe, matter ought to be conſidered as continually

nually paſſing from one ſtate to another, and conſtituting elements more and more active.

3. A little afterwards, he heſitates not to affirm, that in proportion as the matter decompounds itſelf, it becomes more ſubtle, and that the ſwiftneſs of thoſe bodies increaſes in proportion to their littleneſs. He ſays, that every combination of matter reduces itſelf at laſt to ſuch ſimple parts, as thoſe are of reſiſtance and motion; that reſiſtance and motive activity, are the effect of ſimple energies; and in ſhort, that a number of beings ſimple and unextended, may contribute to give us an idea of an extended combination of them, diviſible and ſubſtantial. He ſays afterwards, that the principles of matter are ſubſtances, in which all eſſence, exiſtence, and action, terminate in their laſt reſort, and that there are active principles in the univerſe, which are naturally productive of motion. In ſhort, he concludes with ſaying, that matter, carried to its firſt principles, is no longer an unactive maſs, but becomes at length, activity itſelf, endowed with the powers of repulſion, motion, and life, and that every particle of it partakes of ſenſations; and in another place he ſays, that there is a perceivable life in every particle; and in ſhort, that there is a real active force in matter.*

4. If we compare this ſyſtem with that of the ancients, we ſhall eaſily diſcover a ſtriking conformity. Pythagoras and Plato taught, that all nature was animated, and that matter had in itſelf a principle of motion and reſt, that held it always in action; which is no other, according to the ſyſtem of Mr. Needham, than active, combined with repelling force.

5. The Pythagoreans believed, that the world was animated; that there was a principle of vitality infuſed through the whole of nature, which extended itſelf not only through the animal kingdom, but through the vegetable, by a ſucceſſion conſtant and perpetual; they acknowledged a productive force, an active prin-

* Absurd to the last degree.

ciple

ciple through matter, which penetrated all, and put all in motion, and which was the ſoul of the world, or the force impreſſed by God on nature.

6. And it is this which Mr. Needham calls the active principles through the univerſe, which of themſelves produce motion, or the perceptive vitality in every particle; that motive, or repulſive activity, which Plato alſo joined to matter as an active principle, which held all from the beginning, in an irregular and indetermined movement; and which, from the foundation of the world, was regulated by God, and directed according to his eternal laws; and that great philoſopher poſitively ſays, that God has not created matter inert and inactive; but hath only prevented it from being blindly agitated.

7. Mr. Needham indeed ſays, that every natural combination can, at laſt, reſolve itſelf into its natural principles, endowed with reſiſtance and motion; and that a number of ſimple and indiviſible principles might concur to give us an idea of extended combinations of them, diviſible, and ſubſtantial: yet Plato long before had clearly diſtinguiſhed, with the philoſophers of his own times, the matter of which bodies are compoſed from the bodies themſelves. He remarked an eſſential difference between that matter, which enters into the compoſition of all bodies, and the bodies themſelves. And Stobæus, explaining Plato's ſentiments, agrees, that matter is corporeal, but at the ſame time warns us not to confound it with the bodies themſelves; becauſe, ſays he, it is deſtitute of the eſſential qualities of body; ſuch as figure, weight, lightneſs, &c. although it contains in it an aptitude to motion, diviſibility, and the reception of different forms: and another great Grecian philoſopher hath alſo ſaid, almoſt in the ſame terms with Mr. Needham, that the ideas of force, impenetrability, and weight, concur to give us an idea of bodies.

8. Pythagoras, Plato, and Ariſtotle, held a ſentiment reſpecting generation, to which that of Mr. Needham's

ham's evidently refers: this author ſays, that the firſt ſource of vegetation, or its primitive bud, is formed all at once, and ſpecifically determined: that it is the firſt thing in motion, that it commences vegetation, and that afterwards heat concurs to aſſiſt its expanſive force. Now is it not this which the ancient philoſophers meant, when they ſaid, that the ſeminal force was incorporeal, and acted upon bodies as much as ſpirit did? And Democritus and Strabo have explained themſelves hereupon with ſtill more dignity, when they call its energy ſpiritual, and convertive of bodies into itſelf.

CHAP. IX.

Of Thunder, and Earthquakes; of the Virtue of the Magnet; of the Ebbing and Flowing of the Sea; and of the Source of Rivers.

1. I Go on to ſome articles of Natural Philoſophy, where I ſhall endeavour to ſhew the conformity there is between the ancients, and ſome of our moſt celebrated philoſophers. It is evident, that the cauſes of thunder, earthquakes, the attractive force of the loadſtone, the ebbing and flowing of the ſea, and the return of rivers to their ſource, were not hid from the former; nor was it their fault, that the ſentiments they ſo long ago held on theſe ſubjects, were either not adopted, or not till very lately. It ought not to be objected here, that the diverſity of opinions among them was ſo great, that it was difficult to determine which to chuſe; unleſs, at the ſame time, it be acknowledged, that the ſame holds true with reſpect to the equal variety that reigns at preſent among us. It is not long ago, that two or three different ſets of notions were raiſed

raiſed up againſt thoſe of Sir Iſaac Newton, reſpecting colours; but that did not impede the triumph of his ſyſtem, nor ſtrip him of the glory of having propoſed, what, beyond all others, was moſt juſt and ſolid.

2. The moderns are divided into two opinions as to what occaſions thunder; ſome of them aſſigning the cauſe of it to inflamed exhalations, rending the clouds wherein they are confined; others aſcribing it to the ſhock that happens between two or more clouds, when thoſe that are higher and more condenſed, fall upon thoſe that are lower, with ſo much force as ſuddenly to expel the intermediate air, which vigorouſly expanding itſelf, in order to occupy its former ſpace, puts all the exterior air in commotion, producing thoſe reiterated claps which we call thunder. I ſtop not to examine a third theory, which makes the matter productive of thunder, the ſame with that which is the cauſe of electricity; for though it be the moſt probable of any, yet the truth of it is ſtill conteſted.

3. Of thoſe two ſentiments of the ancients, which have been adopted by our moderns, the latter belongs to Ariſtotle, who ſays, that thunder is cauſed by a dry exhalation, which falling upon a humid cloud, and violently endeavouring to force a paſſage for itſelf, produces the peals which we hear. And Anaxagoras refers it to the ſame cauſe. All the other paſſages, which occur in ſuch abundance among the ancients, reſpecting the formation of thunder, evidently contain the reaſonings of the Newtonians, and ſometimes join together the two ſentiments which divide the moderns.

4. Leucippus held, that thunder proceeded from a fiery exhalation, which encloſed in a cloud, burſt it aſunder, and forced its way through. Democritus aſſerts, that it is the effect of a mingled collection of various volatile particles, which impel downwards the cloud which contains them, till by the rapidity of their motion, they ſet themſelves and it on fire. Seneca aſcribes it to a dry ſulphureous exhalation ariſing out of the earth, which he calls the aliment of lightning;

and

and which, becoming more and more ſubtilized in its aſcent, at laſt takes fire in the air, and produces a violent eruption.

5. The Stoics diſtinguiſhed two things in thunder, the lightning and the noiſe. According to them, thunder was occaſioned by the ſhock of clouds; and lightning was the combuſtion of the volatile parts of the cloud, ſet on fire by the ſhock: and Chryſippus, taught that lightning was the reſult of clouds being ſet on fire by winds, which daſhed them one againſt another; and that thunder was the noiſe produced by that re-encounter: he added, that theſe effects were coincident; our perception of the lightning before the thunder-clap, being entirely owing to our ſight being quicker than our hearing.

6. There is but one opinion reſpecting the cauſe of earthquakes, which deſerves any notice; and it is that of the Carteſians, Newtonians, and all our other able naturaliſts. They aſcribe it to the earth's being filled with cavities of a vaſt extent, containing in them an immenſe quantity of thick exhalations, of a fuliginous ſubſtance, reſembling the ſmoke of an extinguiſhed candle, which being eaſily inflammable, and by their agitation catching fire, rarefy and heat the central and condenſed air of the cavern to ſuch a degree, that finding no vent to iſſue it, it burſts its encloſements; and in doing this, ſhakes the earth all around with dreadful percuſſions, producing all the other effects which naturally follow.

7. This ſame reaſon is given by Ariſtotle and Seneca, in aſſigning the cauſe of ſuch dreadful events. The former, after refuting thoſe who aſcribed earthquakes to the earth itſelf, or the water it contains, ſubjoins his own opinion, that they were occaſioned by the efforts of the internal air in diſlodging itſelf from the bowels of the earth; and he obſerves, that on the approach of an earthquake, the weather is generally ſerene, becauſe that ſort of air which occaſions commotions in the

the atmoſphere, is at the ſame time pent up in the entrails of the earth.

8. Seneca is ſtill more preciſe; we might take him for a naturaliſt of the preſent times. He ſuppoſes, that the earth hides in its boſom many ſubterraneous fires, which uniting their flames, neceſſarily put into fervid motion the congregated vapours of its cells, which finding no immediate outlet, exert their utmoſt powers, till at laſt they force a way through whatever oppoſes them. He ſays alſo, that if the vapours be too weak to burſt the barriers which retain them, all their efforts end in weak ſhocks, and hollow murmurs without any fatal conſequence.

9. Of all the ſolutions that ever were attempted to be given of the ebbing and flowing of the ſea, the moſt ſimple and ingenious, is, that of Kepler and Sir Iſaac Newton. It is founded on this hypotheſis, that the moon attracts the waters of the ſea, diminiſhing the weight of all thoſe parts of it over whoſe zenith it comes, and increaſing the weight of the collateral parts, ſo that the parts directly oppoſite to the moon, and under it in the ſame hemiſphere, muſt become more elevated than the reſt. According to this ſyſtem, the action of the ſun concurs with that of the moon, in occaſioning the tides; which are higher or lower reſpectively, according to the ſituation of thoſe two luminaries, which, when in conjunction, act in concert, raiſing the tides to the greateſt height; and when in oppoſition, produce nearly the ſame effect, in ſwelling the waters of the oppoſite hemiſpheres; but when in quadrature, ſuſpend each others force, ſo as to act only by the difference of their powers: and thus the tides vary, according to the different poſitions of thoſe luminaries.

10. Pliny's account agrees with this. "That great naturaliſt maintained, that the ſun and moon had a reciprocal ſhare in cauſing the tides; and after a courſe of obſervations for many years, remarked that the moon acted moſt forcibly upon the waters, when it was

neareſt

neareſt to the earth, but that the effect was not immediately perceived by us, but at ſuch an interval as may well take place between the action of celeſtial cauſes, and the diſcernible reſult of them on earth." He remarked alſo that the waters, which are naturally inert, do not ſwell up immediately upon the conjunction of the ſun and moon; but having gradually admitted the impulſe, and begun to raiſe themſelves, continue in that elevation, even after the conjunction is over.

11. There are few things which have more engaged the attention of naturaliſts, and with leſs ſucceſs, than the wonderful properties of the loadſtone. At all times men have hazarded a variety of conjectures, to account for the curious effects of it. Almoſt all have agreed in aſſigning this as a principal reaſon, that there are corpuſcles of a peculiar form and energy, that continually circulate around and through the loadſtone, and a vortex of the ſame matter, circulating around and through the earth. Upon theſe ſuppoſitions, the modern philoſophers have advanced, that the loadſtone hath two poles, ſimilar to thoſe of the earth; and that the magnetic matter which iſſues at one of the poles, and circulates around to enter at the other, occaſions that impulſe which brings iron to the loadſtone, whoſe ſmall corpuſcles have an analogy to the pores of iron, fitting them to lay hold of it, but not of other bodies. This is almoſt all that hath been reaſonably advanced with reſpect to the virtue of the magnet, and all this the ancients had ſaid before.

12. This impulſive force, which joins iron to the loadſtone, and other things to amber, was known to Plato; though he would not call it attraction, as allowing no ſuch cauſe in nature. This philoſopher called the magnet, the ſtone of Hercules, becauſe it ſubdued iron, which conquers every thing. Lucretius alſo knew what cauſed this property in the loadſtone, and without doubt furniſhed Deſcartes with his explanation. He admitted, that there was a "vortex of corpuſcles, or magnet matter, which continually circulating around the loadſtone, repelled the intervening air betwixt itſelf and iron. The air thus repelled, the intervening ſpace,

ſays

ſays that philoſopher, became a vacuum; and the iron, finding no reſiſtance, approached with an impulſive force, puſhed on by the air behind it." Plutarch likewiſe is of the ſame opinion. He ſays, "amber attracts none of thoſe things that are brought to it, any more than the loadſtone. That ſtone emits a matter, which reflects the circum-ambient air, and thereby forms a void. That expelled air puts in motion the air before it, which making a circle returns to the void ſpace, driving before it, towards the loadſtone, the iron which it meets in its way." He then propoſes a difficulty, "why the vortex which circulates round the loadſtone, does not make its way to wood or ſtone, as well as iron." He anſwers, like Deſcartes, that "the pores of iron have an analogy to the particles of the vortex circulating about the loadſtone, which yields them ſuch acceſs as they can find in no other bodies, whoſe pores are differently formed."

13. It is ſcarce credible, that the real cauſe of electricity was known to the ancients, though there be indications of it in the work of Timœus Locrenſis, concerning the ſoul of the world, a reſpectable monument of ancient philoſophy. It is true, that modern naturaliſts themſelves are divided on this point, not indeed with reſpect to the general cauſe of electricity, but with regard to the cauſes of the different directions of the electric matter. They do not indeed ſay wherein the eſſence of this matter conſiſts; they only define it by its properties, and explain it by its effects; yet all own, that it is a very ſubtle fluid, reſiding around electric bodies, which upon being put into motion by the friction of thoſe bodies, or any other cauſe, forcibly ruſhes into them, carrying along with it all the minute things contained in its vortex, and producing all the other effects of electricity which we perceive: now this is preciſely what Timœus ſays of it, in giving the reaſon of amber's attracting bodies; this happens, ſays he, becauſe there iſſues from the amber a ſubtle matter, by which it draws other bodies to itſelf.

14. The moderns are alſo divided in their ſentiments, how it comes to paſs, that rivers continually flowing

ing into the ſea, do not ſwell its maſs of waters, ſo as to make it overflow its banks. One of the chief ſolutions of this difficulty is, that rivers return again to their ſource by ſubterraneous paſſages, which nature hath formed for that purpoſe; there being between the ſea and the ſprings of rivers, a circulation analogous to that of blood in the human body. This explanation of the origin of rivers, and the compariſon reſpecting their circulation, is taken from Seneca, who accounts not only for their not overflowing the bed of the ocean, by the ſecret paſſages formed for them by nature to reconduct them to their ſprings; but aſſigns this reaſon why, at their ſprings, they retain nothing of that brackiſhneſs, which they carried with them from the ſea: becauſe, ſays he, they are completely filtrated in that extenſive circuit they make under ground, through winding paths of all dimenſions, and through layers of every ſoil; ſo that they muſt needs return to their ſource, as pure and ſweet as they departed thence.

CHAP. X.

Of Ether, and of the Weight and Elaſticity of the Air.

1. THE moderns underſtand by ether, a very rare fluid beyond the atmoſphere, and penetrating it, infinitely more ſubtle than the air we reſpire, of an immenſe extent, filling all the ſpaces where the celeſtial bodies roll, yet making no ſenſible reſiſtance to their motions. The exiſtence of ſuch a fluid is generally acknowledged, although many authors, even among the moderns, differ about its nature; ſome ſuppoſing it to be a ſort of air, much purer than that which inveſts our globe; others maintaining, that it is a ſubſtance approaching to that of the celeſtial fire, which emanates from the ſun and other ſtars; others make it generically

cally different from all other matter, and its parts finer than thoſe of light; alledging, that the exceeding tenuity of its parts, render it capable of that vaſt expanſive force, which is the ſource of all that preſſure and dilatation whence moſt of the phenomena in nature ariſe; for, by the extreme ſubtilty of its parts, it intimately penetrates all bodies, and exerts its energy every where.

2. But, whatever be the ſentiments now entertained with reſpect to the exiſtence and nature of ether, we find the origin of them all in what the ancients have ſaid on this ſubject. The Stoics firſt of all taught, there was a ſubtle and active fire, which diffuſed itſelf through, and pervaded the whole univerſe; that by the energy of this ethereal ſubſtance, to which they gave the name of ether, all the parts of nature were produced, ſuſtained, preſerved, and linked together: for it embraced every thing, and in it the celeſtial bodies performed their revolutions.

3. Ariſtotle, explaining Pythagoras's opinion of ether, aſcribes the ſame alſo to Anaxagoras, ſaying, that he looked upon the moſt remote ſpaces of the univerſe, as filled with a ſubſtance, called ether by the philoſophers of his time, but which he himſelf underſtood to be a ſubtle and active fire. And Ariſtotle himſelf, in another place, underſtands by ether a fifth element, pure and unalterable, of an active and vital nature, but entirely different from air and fire.

4. Pythagoras, according to Diogenes Laertius, and Hierocles, affirmed, that the air which inveſts our earth, is impure and mixed; but that the air which is above is pure, healthful, and all of a piece. He calls it free-ether, emancipated from all groſs matter, a celeſtial ſubſtance that penetrated at will the pores of all bodies; juſt like that of the Newtonians, which fills all ſpace, without giving any obſtruction to the ſtars in their courſes. And Empedocles, one of the moſt celebrated diſciples of Pythagoras, is quoted by Plutarch, and St. Clemens Alexandrinus, as admitting an ethereal

ethereal ſubſtance, which filled all ſpace, and contained in it all the bodies of the univerſe. Likewiſe Plato, ſpeaking of air, diſtinguiſhes it into two kinds, the one groſs and filled with vapours, which is what we breathe; the other more refined, called ether, in which the celeſtial bodies are immerged and where they roll.

5. The nature of air was no leſs known among the ancients, than that of Ether. They regard it as a general menſtruum, containing all the volatile parts of every thing in nature, which being variouſly agitated, and differently combined in its embrace, produced all that multiplicity of ferments, meteors, tempeſts, and all the other changes in it, which we experience. They were acquainted too with its weight, though the experiments tranſmitted to us relative to this are but few. Ariſtotle appears to have obſerved this quality in it, for he ſpeaks of a veſſel filled with air, as weighing more than one quite empty. Plutarch and Stobœus quote him as teaching that the air in its weight is between that of fire and of earth; and he himſelf, treating of reſpiration, reports the opinion of Empedocles, who aſcribes the cauſe of it to the weight of the air, which by its preſſure inſinuates itſelf with force into the lungs. Plutarch expreſſes in the very ſame terms the ſentiments of Aſclepiades on this ſubject, repreſenting him among other things, as ſaying, that the external air by its weight, opened its way with force into the breaſt. There is ſtill extant a treatiſe of Heron of Alexandria, wherein he conſtantly applies the elaſticity of the air, to produce ſuch effects, as cannot but convince us, that he perfectly underſtood that property of it. And what will appear ſtill more ſurpriſing, is, that Cteſibius, upon the principle of the air's elaſticity, invented wind-guns, which we look upon as a modern contrivance. Philo of Byzantium, gives a very full and exact deſcription of that curious machine, planned upon the property of the air's being capable of condenſation, and ſo conſtructed, as to manage and direct the force of that element, in ſuch a manner, as to carry ſtones with rapidity to the greateſt diſtance. Seneca alſo knew its weight, ſpring, and elaſticity; for he deſcribes

ſcribes the conſtant effort it makes to expand itſelf, when it is impreſſed; and affirms, that it has the property of condenſing itſelf, and forcing its way through all obſtacles that oppoſe its paſſage.

6. The notions moſt generally received reſpecting fire, and its properties, are clearly to be found in Plato, Stobœus, Ariſtotle, and Lucretius; the firſt of whom ſays, that fire is generated of motion, it being the effect of the act and friction of the ſmall particles of bodies. Ariſtotle ſpeaks of ſome philoſophers of his time, who taught, that flame was nothing elſe, but ſmall corpuſcular parts, continually ſucceeding one another in rapid motion; that fire was compoſed of pyramidical particles whoſe ſharp angles ſtung us in entering our pores, and melted metals, by diſcovering their parts, which is what Deſcartes hath repeated from him. Demonax affirms, that fire hath weight. Lucretius does the ſame; adding, that the reaſon of its always appearing to tend upwards, is owing to a foreign cauſe; to wit, the preſſure of the air, which buoys its flame up, and makes it ſeem to mount.

CHAP. XI.

Newton's Theory of Colours, indicated by Pythagoras and Plato.

1. THAT wonderful theory, whereby is inveſtigated and diſtinguiſhed from one another, all that variety of colours which enters into the compoſition of that uniform appearance, light, might of itſelf ſuffice to eſtabliſh for ever the glory of Sir Iſaac Newton, and be an eternal monument of the extraordinary ſagacity of that great man. That diſcovery ſeems, by its importance, to have been reſerved for an age when philoſophy

philoſophy had arrived at its fulleſt maturity; and yet it is to be found among ſome of the eminent men of the firſt antiquity, whoſe genius had no occaſion for the experience of many ages to form it, as is ſtrikingly evident from their having given birth to the ſciences. Of this number are Pythagoras and Plato. The former of whom, and his diſciples after him, entertained ſufficiently juſt conceptions of the formation of colours. They taught, that they reſulted ſolely from the different modifications of reflected light; or, as a modern author, in explaining the ſentiments of the Pythagoreans, expreſſes it, light reflecting itſelf with more or leſs vivacity, forms by that means our different ſenſations of colour. Thoſe ſame philoſophers of the Pythagoric ſchool, in aſſigning the reaſon of the difference of colours, aſcribe it to a mixture of the elements of light; and diveſting the atoms, or ſmall particles of light, of all manner of colour, impute every ſenſation of that kind to the motions excited in our organs of ſight. The diſciples of Plato contributed not a little to the advancement of optics, by the important diſcovery they made, that light emits itſelf in ſtraight lines, and that the angle of incidence is always equal to the angle of reflection.

2. Plato alſo ſeems to have apprehended the Newtonian ſyſtem of colours; for he calls them the effect of Light tranſmitted from bodies, the ſmall particles of which were adapted to the organs of ſight. Now is not this preciſely the ſame with what Sir Iſaac teaches, "That the different ſenſations of each particular colour are excited in us by the difference of ſize in thoſe ſmall particles of light which form the ſeveral rays; thoſe ſmall particles occaſioning different images of colour, as the vibration is more or leſs lively with which they ſtrike our ſenſe?" The ſame philoſopher hath gone further: he hath entered into a detail of the compoſition of colours, and inquired into the viſible effects that muſt ariſe from a mixture of the different rays of which light itſelf is compoſed. And what he advances a little farther on, that it was not in the power of man exactly to determine what the proportion of this mixture

ture ſhould be in certain colours, ſufficiently ſhews, that he had an idea of this theory, though he judged it almoſt impoſſible to unfold it; which makes him add, that ſhould any one arrive at the knowledge of this proportion, he ought not to hazard the diſcovery of it, ſince it would be impoſſible to demonſtrate it by clear and convincing proofs: and yet he thought certain rules might be laid down reſpecting this ſubject, if in following and imitating nature, we could arrive at the art of forming a diverſity of colours, by the combined intermixture of others. And he afterwards adds, what may be regarded as the nobleſt eulogium that ever was made on Sir Iſaac Newton; Yea, ſhould ever any one, exclaims that fine genius of antiquity, attempt by curious reſearch to account for this admirable mechaniſm, he will, in doing ſo, but manifeſt how entirely ignorant he is of the difference between divine and human power. It is true, God can intermingle thoſe things one with another, and then ſerve them at his pleaſure, becauſe he is, at the ſame time, all-knowing and all-powerful; but there is no man now exiſts, nor ever will perhaps, who ſhall ever be able to accompliſh things ſo very difficult. What an eulogium are theſe words in the mouth of ſuch a philoſopher as Plato, and how glorious is he who hath ſucceſsfully accompliſhed what appeared impracticable to that prince of philoſophers! And what elevation of genius, what piercing penetration into the moſt intimate ſecrets of nature, diſplays itſelf in what we have juſt now recited from Plato, concerning the nature and theory of colours, at a time when philoſophy was but yet in its infancy!

3. Although the ſyſtem of Deſcartes, reſpecting the propagation of light in an inſtant, is ſcarcely admitted at preſent by the moſt part of philoſophers, nor has been ever ſince Meſſrs. Caſſini and Romer diſcovered that its motion was progreſſive; yet as that ſyſtem was for a long while in vogue, and the whole honour of the invention of it aſcribed to Deſcrates, it will not be amiſs, in a few words, to make appear, that he drew the idea of it from Ariſtotle and his commentators. The opinion of the modern philoſophers is, that light is nothing

elſe but the action of a ſubtle matter upon the organs of ſight. This ſubtle matter is ſuppoſed to fill all that ſpace which lies between the ſun and us; and that particle of it, which is next to the ſun, receiving thence an impulſe, muſt inſtantaneouſly communicate it to all the reſt which lie between the ſun and the organ of ſight. To render this the more evident, Deſcartes introduces the compariſon of a ſtick; which by reaſon of the continuity of its parts, cannot in any degree be moved lengthways at one end, without inſtantaneouſly being put into the ſame degree of motion at the other end.

4. Whoever will be at the pains attentively to read what Ariſtotle hath written concerning light, without having recourſe to the ridiculous interpretations that have been put upon his words, will clearly diſcern, that he was far from being ſo unacquainted with the truth in this caſe, as is generally thought. He defines it to be the action of a ſubtle, pure, and homogeneous matter; and Philoponus, explaining the manner in which this action was performed, makes uſe of the inſtance of a long ſtring, which being pulled at one end, will inſtantaneouſly be moved at the other. In that very place, he reſembles the ſun, to the man who pulls the ſtring; the ſubtle matter, to the ſtring itſelf; and the inſtaneous action of the one, to the movement of the other. Simplicius, in his commentary upon this paſſage of Ariſtotle, expreſsly employs the motion of a ſtick, to imitate how light, acted upon by the ſun, may inſtantaneouſly impreſs the organs of ſight. The compariſon of a ſtick, to convey an idea of the celerity with which light may communicate itſelf, ſeems to have been firſt of all made uſe of by Chryſippus.

CHAP.

CHAP. XII.

Of Burning Glasses.

1. THE fertile genius of Archimedes illuſtriouſly appears, not only in thoſe works of his which have been handed down to us, but alſo in the admirable deſcriptions which the authors of his time have given us of his diſcoveries in mathematics and mechanics. Some of the inventions of this great man have appeared ſo far to ſurpaſs human ability and imagination, that ſome celebrated philoſophers have called them in queſtion, and even gone ſo far as to pretend to demonſtrate their impoſſibility. I intend in this chapter to examine into the ſubject of the burning glaſſes, employed by Archimedes to ſet fire to the Roman fleet at the ſiege of Syracuſe. Kepler, Naudeus, and Deſcartes, have treated it as a mere fable, though the reality of it hath been atteſted by Diodorus Siculus, Lucian, Dion, Zonaras, Galen, Anthemius, Euſtathius, Tzetzes, and others. Nay, ſome have even pretended to demonſtrate by the rules of Catoptics the impoſſibility of it, notwithſtanding the aſſervation of ſuch reſpectable authors, who ought to have prevented them from rejecting ſo lightly a fact ſo well ſupported.

2. Yet all have not been involved in this miſtake. Father Kircher, attentively obſerving the deſcription which Tzetzes gives of the burning glaſſes of Archimedes, reſolved to prove the poſſibility of this; and having by means of a number of plain mirrors, collected the ſun's rays into one focus, he ſo augmented the ſolar heat, that at laſt by increaſing the number of mirrors he could produce the moſt intenſe degree of it.

3. Tzetzes's deſcription of the glaſs Archimedes made uſe of, is indeed proper to raiſe ſuch an idea as Kircher entertained. That author ſays, Archimedes ſet fire to Marcellus' navy, by means of a burning glaſs compoſed of ſmall, ſquare mirrors, moving every way upon hinges; which when placed in the ſun's rays, directed them upon the Roman fleet, ſo as to reduce it to aſhes at the diſtance of a bow-ſhot. It is probable Mr. de Buffon availed himſelf of this deſcription, in conſtructing his burning glaſs, compoſed of 168 little plain mirrors, which produced ſo conſiderable a heat, as to ſet wood in flames at the diſtance of two hundred and nine feet; melt led, at that of one hundred and twenty; and ſilver, at that of fifty.

4. Another teſtimony occurs, which leaves not the leaſt doubt in this caſe. Anthemius of Tralles in Lydia, a celebrated architect, able ſculptor, and learned mathematician, who in the Emperor Juſtinian's time built the Church of St. Sophia at Conſtantinople, wrote a ſmall treatiſe in Greek, which is extant only in manuſcript, entitled Mechanical Paradoxes. That work, among other things, has a chapter reſpecting burning glaſſes, where we meet with the moſt complete deſcription of the requiſites that Archimedes muſt have been poſſeſſed of, to enable him to ſet fire to the Roman fleet. He begins with this inquiry, "How in any given place, at a bow-ſhot's diſtance, a conflagration may be raiſed by means of the ſun's rays?" And immediately lays it down as a firſt principle. "The ſituation of the place muſt be ſuch, that the rays of the ſun may be reflected upon it in an oblique, or even oppoſite direction, to that in which they came from the ſun itſelf." And he adds, "that the aſſigned diſtance being ſo conſiderable, it might appear at firſt impoſſible to effect this by means of the reflection of the ſun's rays; but as the glory Archimedes had gained by thus ſetting fire to the Roman veſſels, was a fact univerſally agreed in, he thought it reaſonable to admit the poſſibility of it, upon the principle he had laid down." He afterwards advances farther in this inquiry, eſtabliſhing certain neceſſary propoſitions in order

der to come at a ſolution of it. "To find out therefore in what poſition a plain mirror ſhould be placed to carry the ſun's rays by reflection to a given point, he demonſtrates that the angle of incidence is equal to the angle of reflection; and having ſhewn, that in ſo juſt a poſition of the glaſs, the ſun's rays might be reflected to the given place, he obſerves, that by means of a number of glaſſes, reflecting the rays into the ſame focus, there muſt ariſe at the given place the conflagration required, for inflaming heat is the reſult of thus concentrating the ſun's rays: and that when a body is thus ſet on fire, it kindles the air around it, ſo that it comes to be acted upon by the two forces at once, that of the ſun, and that of the circum-ambient air, reciprocally augmenting and increaſing the heat;" whence continues he, "it neceſſarily reſults, that by a proper number of plain mirrors duly diſpoſed, the the ſun's rays might be reflected in ſuch quantity into a common focus at a bow-ſhot diſtance, as to ſet all in flames around it.

5. "As to the manner of putting this in practice" he ſays, "it might be done by employing many hands to hold the mirrors in the deſcribed poſition; but to avoid the confuſion that might thence ariſe, twenty-four mirrors at leaſt being requiſite to communicate flame at ſuch a diſtance, he fixes upon another method, that of a plain hexagon mirror, accommodated on every ſide by leſſer ones, adhering to it by means of plates, bands or hinges, connecting them mutually together, ſo as to be moved or fixed at pleaſure in any direction. Thus having adapted the large or middle mirror to the rays of the ſun, ſo as to point them to the given place, it will be eaſy in the ſame manner to diſpoſe the reſt, ſo that all the rays together may meet in the ſame focus: and multiply compound mirrors of this kind, and giving them all the ſame direction, there muſt thence infallibly reſult, to whatever degree of intenſeneſs, the conflagration required at the place given."

6. "The better to ſucceed in this enterprize, there ſhould be in readineſs" he adds, "a conſiderable number

ber of theſe compound mirrors to act all at once, from four at leaſt to ſeven." He concludes his diſſertation with obſerving, " that all the authors who mention the burning machine of the divine Archimedes, never ſpeak of it as of one compound mirror, but as a combination of many." So large and accurate a deſcription is more than ſufficient to demonſtrate the poſſibility of a fact, ſo well atteſted in hiſtory, and by ſuch a number of authors, that it would be the higheſt arrogance, to refuſe our ſuffrage to ſuch invincible teſtimony. Vitellion, who lived about the 13th century, ſpeaks of a work of Anthemius of Tralles, who had compoſed a burning glaſs, conſiſting of twenty-four mirrors, which conveying the rays of the ſun into a common focus, produced an extraordinary degree of heat. And Lucian, ſpeaking of Archimedes, ſays, " that at the ſiege of Syracuſe he reduced, by a ſingular contrivance, the Roman ſhips to aſhes. And Galen; that with burning glaſſes, he fired the ſhips of the enemies of Syracuſe." Zonaras alſo ſpeaks of Archimedes' glaſſes, in mentioning thoſe of Proclus, who, he ſays, " burnt the fleet of Vitellius at the ſiege of Conſtantinople, in imitation of Archimedes, who ſet fire to the Roman fleet at the ſiege of Syracuſe." He intimates, that the manner wherein Proclus effected this, was by launching upon the enemies' veſſels, from the ſurface of reflecting mirrors, ſuch a quantity of flame, as reduced them to aſhes.

7. Euſtathius, in his commentary upon the Iliad, ſays, " that Archimedes, by a catoptic machine, burnt the Roman fleet, at a bow-ſhot's diſtance." Inſomuch, that there is ſcarcely any fact in hiſtory, warranted by more authentic teſtimony; ſo that it would be difficult not to ſurrender to ſuch evidence, even although we could not comprehend how it were poſſible for Archimedes to have conſtructed ſuch glaſſes: but now that the experiment of Father Kircher, and Mr. de Buffon have made it apparent, that nothing is more eaſy in the execution, than what ſome gentlemen have denied the poſſibility of; what ought they to think of the genius of that man, whoſe inventions even by their own accounts,

counts, ſurpaſs the conception of the moſt celebrated mathematicians of our days, who think they have done ſomething very extraordinary, when they have ſhewed themſelves capable of imitating in ſome degree the ſketches of thoſe great maſters, of whom, however, they are very unwilling to be thought the diſciples?

8. Again, it appears that the Ancients were acquainted with refracting burning glaſſes; for we find in Ariſtophanes's Comedy of the Clouds, a paſſage which clearly treats of the effects of thoſe glaſſes. The author introduces Socrates as examining Strepſiades, about the method he had diſcovered for getting clear for ever of his debts. He replies, that he thought of making uſe of a burning glaſs, which he had hitherto uſed in kindling his fire; for ſays he, ſhould they bring a writ againſt me, I'll immediately place my glaſs in the ſun, at ſome little diſtance from the writ, and ſet it on fire. Where we ſee he ſpeaks of a glaſs which burned at a diſtance, and which could be no other than a convex glaſs. Pliny and Lactantius have alſo ſpoken of glaſſes that burnt by refraction. The former calls them balls or globes of glaſs, or cryſtal, which expoſed to the ſun, tranſmit a heat ſufficient to ſet fire to cloth, or corrode away the dead fleſh of thoſe patients who ſtand in need of cauſtics? and the latter, after Clemens Alexandrinus, takes notice, that fire may be kindled, by interpoſing glaſſes filled with water, between the ſun and the object, ſo as to tranſmit the rays to it.

CHAP.

CHAP. XIII.

Of universal Gravity, and centripetal and centrifugal Force.

Laws of the Movement of the Planets, according to their Distance from the common Centre.

1. IT is here the moderns flatter themſelves they have a remarkable advantage, imagining, that they were the firſt who diſcovered the principal of univerſal gravitation, which they look upon as a truth unknown to the ancients. It is however eaſy to make it appear, that they have done nothing but trod in the paths of thoſe ancients. It is true, the moderns have demonſtrated the laws of this univerſal gravitation, and explained them with clearneſs and preciſion; but this is all they have done in this reſpect, and have added nothing.

2. With the leaſt attention to the knowledge of the ancients, we find that they were not unacquainted with univerſal gravitation; and knew beſides, that the circular motion, by which the planets deſcribe their courſe, is the reſult of the combination of two moving forces, a rectilinear and a perpendicular, which united together form a curve. They knew the reaſon why theſe two movements, or contrary forces, retain the planets in their orbs; and have explained themſelves on this head, juſt as the moderns do, excepting only the terms of centripetal and centrifugal; inſtead of which, however, they uſed what was altogether equivalent. They alſo knew the inequality of the courſe of the planets, aſcribing it to the variety of their weights reciprocally conſidered, and of their proportional diſtances.

3. I will

3. I will not expatiate upon Empedocle's ſyſtem, in which ſome have thought the foundation of Newton's was to be found; imagining, that under the name of love, he intended to intimate a law, or power, which ſeparated the parts of matter, in order to join himſelf to them, and to which nothing was wanting but the name of attraction. One ſees alſo, that by the name diſcord, he intended to deſcribe another force, which obliged the ſame parts to recede from one another, and which Newton calls a repelling force. But I leave Empedocles, and paſs on to paſſages more deſerving notice.

4. The Pythagoreans and Platonics, treating of the creation of the world, perceived the neceſſity of admitting the force of two powers, viz. projection and gravity, in order to account for the revolution of the planets. Timœus, ſpeaking of the ſoul of the world, which puts all nature in motion, ſays, "that God hath endowed it with two powers, which, in combination, act according to certain numeric proportions." Plato, who hath followed Timœus in his natural philoſophy, clearly aſſerts, that God had impreſſed upon the planets a motion which was the moſt proper for them; which could be nothing elſe than the perpendicular motion, which has a tendency to the centre of the univerſe, that is, gravity; and what in this caſe coincides with it, a lateral impulſe, rendering the whole circular. And Diogenes Laertius, alluding in all likelihood to this paſſage of Plato, ſays, that at the beginning, the bodies of the univerſe were agitated tumultuouſly, and with a diſorderly movement, but that God afterwards regulated their courſe, by laws natural and proportional.

5. Anaxagoras cited by Diogenes Laertius, being aſked what it was that retained the heavenly bodies in their orbit, notwithſtanding their gravity; anſwered, that the rapidity of their courſe preſerved them in their ſtations; and ſhould the celerity of their motions abate, the equilibrium of the world being broke, the whole machine would fall to ruin.

6. Plutarch, who knew almoſt all the ſhining truths

of aſtronomy, took notice alſo of the reciprocal energy, which cauſes the planets to gravitate towards one another; and in explaining what it was that made bodies tend towards the earth, he attributes it to a reciprocal attraction, whereby all terreſtrial bodies have this tendency, and which collects into one the parts conſtituting the ſun and moon, and retains them in their ſpheres. He afterwards applies theſe particular phenomena to others more general; and from what happens in our globe, deduces, according to the ſame principle, whatever muſt thence happen reſpectively in each celeſtial body; and then conſiders them in their relative connections one towards another. He illuſtrates this general connection, by inſtancing what happens to our moon in its revolution round the earth, comparing it to a ſtone in a ſling, which is impreſſed by two powers at once; that of projection, which would carry it away, were it not retained by the embrace of the ſling; which, like the central force, keeps it from wandering, whilſt the combination of the two moves it in a circle. In another place, he ſpeaks of an inherent power in bodies; that is, in the earth; and other planets; of attracting to themſelves whatever is within their reach. It is impoſſible, not to perceive in all theſe paſſages, a plain reference to the centripetal force, which binds the planets to their proper or common centres; and to the centrifugal, which makes them roll in circles at a diſtance.

7. We have ſeen, that the ancients attribute to the celeſtial bodies, a tendency towards one common centre, and a reciprocal attractive power. Lucretius well perceived this truth, though he deduced from it a very ſtrange conſequence, that the univerſe had no common centre, but that infinite ſpace was filled with an infinity of worlds like ours: for, ſays he, if the celeſtial bodies were all of them carried towards one common centre, and not reſtrained from that tendency by ſome exterior active force, they muſt needs ſoon diverge towards one another, by virtue of their attractive power, and like bodies tumbling from on high, re-unite at the common centre of gravity, and coaleſce into one infinite inactive maſs.

8. It

8. It appears alſo, that the ancients knew, as well as the moderns, the cauſe of gravitation, which attracted all things, did not reſide ſolely in the centre of the earth. Their ideas were more philoſophic; that this power was diffuſed through every particle of the terreſtrial globe, and compounded of the various energy reſiding in each.

9. It remains to inquire, whether the ancients knew the law by which gravity acts upon the celeſtial bodies; that it was in an inverſe proportion of their quantity of matter, and the ſquare of their diſtance. Certain it is, that the ancients were not ignorant, that the planets in their courſes obſerved a conſtant and invariable proportion; and that they had different opinions reſpecting this proportion. Some ſought for it in the difference of the quantity of matter contained in the maſſes, of which they were compoſed; and others, in the difference of their diſtances. Lucretius, after Democritus and Ariſtotle, thought that the gravity of bodies was in proportion to the quantity of matter of which they were compoſed; and the ableſt Newtonians, even ſuch as ought to be the moſt intereſted to preſerve to their maſter the glory of having firſt diſcovered thoſe truths, which are the principal ornaments of his ſyſtem have been the firſt to point at the ſources whence they ſeem to have been drawn. It is true, the penetration and ſagacity of a Newton, a Gregory, and a Maclaurin, were requiſite to diſcover, in the few fragments now remaining, the inverſe law reſpecting the ſquares of the diſtances, a doctrine which Pythagoras had taught; but it is no leſs true, that it was contained in thoſe writings. This the Newtonians acknowledge, and are the firſt to avail themſelves of the authority of Pythagoras, to give weight to their ſyſtem.

10. Plutarch, of all the philoſophers who have ſpoken of Pythagoras, is he, who, as he had a better opportunity of entering into the ideas of that great man, hath explained them better than any one beſides. Pliny, Macrobius, and Cenſorinus, have alſo ſpoken of the harmony which Pythagoras obſerved to reign in

the

the courſe of the planets. Plutarch makes him ſay, it is probable that the bodies of the planets, their diſtances, the intervals between their ſpheres, and the celerity of their courſes and revolutions, are not only proportionable among themſelves, but to the whole of the univerſe. And Gregory hath been led to declare, it was evident to any attentive mind, that this great man underſtood, that the gravitation of the planets towards the ſun, was in a reciprocal ratio of their diſtance from that luminary; and that illuſtrious modern, followed herein by Maclaurin, makes that ancient philoſopher ſpeak thus:

11. "A muſical ſtring, ſays Pythagoras, yields the very ſame tone with any other of twice its length, becauſe the tenſion of the latter, or the force whereby it is extended, is quadruple to that of the former; and the gravity of one planet, is quadruple to that of any other, which is at double the diſtance. In general, to bring a muſical ſtring into uniſon with one of the ſame kind, ſhorter than itſelf, its tenſion ought to be increaſed in proportion as the ſquare of its length exceeds that of the other; and that the gravity of any planet, may become equal to that of any other nearer the ſun, it ought to be increaſed in proportion as the ſquare of its diſtance exceeds that of the other. If therefore, we ſhould ſuppoſe muſical ſtrings ſtretched from the ſun to each of the planets, it would be neceſſary, in order to bring them all to uniſon, to augment or diminiſh their tenſions, in the very ſame proportion as would be requiſite to render the planets themſelves equal in gravity. And this, in all likelihood, gave foundation for the reports, that Pythagoras drew his doctrine of harmony from the ſpheres."

12. Before I finiſh this chapter, I muſt not neglect to inſert a paſſage of Galileo's, wherein he acknowledges, that he owes to Plato his firſt idea of the method of determining, how the different degrees of velocity, ought to produce that uniformity of motion diſcernable in the revolutions of the heavenly bodies. His account is, "Plato being of opinion, that no moveable

ble thing could paſs from a ſtate of reſt to any determinate degree of velocity, ſo as perpetually and equally to remain in it, without firſt paſſing through all the inferior degrees of celerity or retardation; concludes thence, that God, after having created the celeſtial bodies, determining to aſſign to each a particular degree of celerity, in which they ſhould always move, impreſſed upon them, when he drew them from a ſtate of reſt, ſuch a force as made them run through their aſſigned ſpaces, in that natural and direct way wherein we ſee the bodies around us paſs from reſt into motion, by a continual and ſucceſſive acceleration. And he adds, that having brought them to that degree of motion, wherein he intended they ſhould perpetually remain; he afterwards changed the perpendicular into a circular direction, that being the only courſe that can preſerve itſelf uniform, and make a body without ceaſing keep at an equal diſtance from its proper centre." This acknowledgment of Galileo is the more remarkable, as it comes from an inventive genius, who leaſt of any, owes his eminence to the aid of the ancients; for it is the diſpoſition of noble minds to arrogate to themſelves as little as poſſible any merit, but what they have the utmoſt claim to. Thus do Galileo and Newton, the greateſt of all modern philoſophers, ſet an example which will never be imitated but by thoſe of their own claſs.

CHAP. XIV.

Of the Copernican System; the Motion of the Earth about the Sun; and the Antipodes.

1. THERE are other truths, taught by the ancients long ago, and at laſt adopted by the moderns; after having undergone a not uncommon fate, that of being rejected and condemned with diſdain. That the earth moves about the ſun, and that there are antipodes,

of aſtronomy, took notice alſo of the reciprocal energy, which cauſes the planets to gravitate towards one another; and in explaining what it was that made bodies tend towards the earth, he attributes it to a reciprocal attraction, whereby all terreſtrial bodies have this tendency, and which collects into one the parts conſtituting the ſun and moon, and retains them in their ſpheres. He afterwards applies theſe particular phenomena to others more general; and from what happens in our globe, deduces, according to the ſame principle, whatever muſt thence happen reſpectively in each celeſtial body; and then conſiders them in their relative connections one towards another. He illuſtrates this general connection, by inſtancing what happens to our moon in its revolution round the earth, comparing it to a ſtone in a ſling, which is impreſſed by two powers at once; that of projection, which would carry it away, were it not retained by the embrace of the ſling; which, like the central force, keeps it from wandering, whilſt the combination of the two moves it in a circle. In another place, he ſpeaks of an inherent power in bodies; that is, in the earth, and other planets; of attracting to themſelves whatever is within their reach. It is impoſſible, not to perceive in all theſe paſſages, a plain reference to the centripetal force, which binds the planets to their proper or common centres; and to the centrifugal, which makes them roll in circles at a diſtance.

7. We have ſeen, that the ancients attribute to the celeſtial bodies, a tendency towards one common centre, and a reciprocal attractive power. Lucretius well perceived this truth, though he deduced from it a very ſtrange conſequence, that the univerſe had no common centre, but that infinite ſpace was filled with an infinity of worlds like ours: for, ſays he, if the celeſtial bodies were all of them carried towards one common centre, and not reſtrained from that tendency by ſome exterior active force, they muſt needs ſoon diverge towards one another, by virtue of their attractive power, and like bodies tumbling from on high, re-unite at the common centre of gravity, and coaleſce into one infinite inactive maſs.

8. It

8. It appears alſo, that the ancients knew, as well as the moderns, the cauſe of gravitation, which attracted all things, did not reſide ſolely in the centre of the earth. Their ideas were more philoſophic; that this power was diffuſed through every particle of the terreſtrial globe, and compounded of the various energy reſiding in each.

9. It remains to inquire, whether the ancients knew the law by which gravity acts upon the celeſtial bodies; that it was in an inverſe proportion of their quantity of matter, and the ſquare of their diſtance. Certain it is, that the ancients were not ignorant, that the planets in their courſes obſerved a conſtant and invariable proportion; and that they had different opinions reſpecting this proportion. Some ſought for it in the difference of the quantity of matter contained in the maſſes, of which they were compoſed; and others, in the difference of their diſtances. Lucretius, after Democritus and Ariſtotle, thought that the gravity of bodies was in proportion to the quantity of matter of which they were compoſed; and the ableſt Newtonians, even ſuch as ought to be the moſt intereſted to preſerve to their maſter the glory of having firſt diſcovered thoſe truths, which are the principal ornaments of his ſyſtem have been the firſt to point at the ſources whence they ſeem to have been drawn. It is true, the penetration and ſagacity of a Newton, a Gregory, and a Maclaurin, were requiſite to diſcover, in the few fragments now remaining, the inverſe law reſpecting the ſquares of the diſtances, a doctrine which Pythagoras had taught; but it is no leſs true, that it was contained in thoſe writings. This the Newtonians acknowledge, and are the firſt to avail themſelves of the authority of Pythagoras, to give weight to their ſyſtem.

10. Plutarch, of all the philoſophers who have ſpoken of Pythagoras, is he, who, as he had a better opportunity of entering into the ideas of that great man, hath explained them better than any one beſides. Pliny, Macrobius, and Cenſorinus, have alſo ſpoken of the harmony which Pythagoras obſerved to reign in

the

the courſe of the planets. Plutarch makes him ſay, it is probable that the bodies of the planets, their diſtances, the intervals between their ſpheres, and the celerity of their courſes and revolutions, are not only proportionable among themſelves, but to the whole of the univerſe. And Gregory hath been led to declare, it was evident to any attentive mind, that this great man underſtood, that the gravitation of the planets towards the ſun, was in a reciprocal ratio of their diſtance from that luminary; and that illuſtrious modern, followed herein by Maclaurin, makes that ancient philoſopher ſpeak thus;

11. "A muſical ſtring, ſays Pythagoras, yields the very ſame tone with any other of twice its length, becauſe the tenſion of the latter, or the force whereby it is extended, is quadruple to that of the former; and the gravity of one planet, is quadruple to that of any other, which is at double the diſtance. In general, to bring a muſical ſtring into uniſon with one of the ſame kind, ſhorter than itſelf, its tenſion ought to be increaſed in proportion as the ſquare of its length exceeds that of the other; and that the gravity of any planet, may become equal to that of any other nearer the ſun, it ought to be increaſed in proportion as the ſquare of its diſtance exceeds that of the other. If therefore, we ſhould ſuppoſe muſical ſtrings ſtretched from the ſun to each of the planets, it would be neceſſary, in order to bring them all to uniſon, to augment or diminiſh their tenſions, in the very ſame proportion as would be requiſite to render the planets themſelves equal in gravity. And this, in all likelihood, gave foundation for the reports, that Pythagoras drew his doctrine of harmony from the ſpheres."

12. Before I finiſh this chapter, I muſt not neglect to inſert a paſſage of Galileo's, wherein he acknowledges, that he owes to Plato his firſt idea of the method of determining, how the different degrees of velocity, ought to produce that uniformity of motion diſcernable in the revolutions of the heavenly bodies. His account is, "Plato being of opinion, that no moveable

ble thing could paſs from a ſtate of reſt to any determinate degree of velocity, ſo as perpetually and equally to remain in it, without firſt paſſing through all the inferior degrees of celerity or retardation; concludes thence, that God, after having created the celeſtial bodies, determining to aſſign to each a particular degree of celerity, in which they ſhould always move, impreſſed upon them, when he drew them from a ſtate of reſt, ſuch a force as made them run through their aſſigned ſpaces, in that natural and direct way wherein we ſee the bodies around us paſs from reſt into motion, by a continual and ſucceſſive acceleration. And he adds, that having brought them to that degree of motion, wherein he intended they ſhould perpetually remain; he afterwards changed the perpendicular into a circular direction, that being the only courſe that can preſerve itſelf uniform, and make a body without ceaſing keep at an equal diſtance from its proper centre." This acknowledgment of Galileo is the more remarkable, as it comes from an inventive genius, who leaſt of any, owes his eminence to the aid of the ancients; for it is the diſpoſition of noble minds to arrogate to themſelves as little as poſſible any merit, but what they have the utmoſt claim to. Thus do Galileo and Newton, the greateſt of all modern philoſophers, ſet an example which will never be imitated but by thoſe of their own claſs.

CHAP. XIV.

Of the Copernican Syſtem; the Motion of the Earth about the Sun; and the Antipodes.

1. THERE are other truths, taught by the ancients long ago, and at laſt adopted by the moderns; after having undergone a not uncommon fate, that of being rejected and condemned with diſdain. That the earth moves about the ſun, and that there are antipodes,

podes, are particulars known ong ago, though received almoſt every where at firſt with contempt or ridicule; nay, they have ſometimes proved dangerous to thoſe who held them; yet both theſe doctrines are now ſo well eſtabliſhed, that they meet with general approbation. And thus, for two ages paſt, have we gone on to re-introduce the moſt celebrated of the ancient opinions; ſtill affecting, however, not to know that we are in any manner indebted to thoſe who firſt held them.

2. The moſt reaſonable in itſelf, and what agrees beſt with the moſt accurate obſervations, is that ſyſtem of the world propoſed by Copernicus, who places the ſun in the centre, the fixed ſtars at the circumference, and the earth and other planets in the intervening ſpace; and who aſcribes to the earth not only a diurnal motion around its axis, but an annual round the ſun This ſyſtem is entirely ſimple, and beſt explains all the appearances of the planets, and their ſituations, whether proceſſional, ſtationary, or retrograde; but it is matter of ſurpriſe, how a ſyſtem ſo fully and diſtinctly inculcated by the ancients, ſhould derive its name from a modern philoſopher. Pythagoras, Philolaüs, Nicetas of Syracuſe, Plato, Ariſtarchus, and many others among the ancients, have in a thouſand places expreſſed this opinion; and Diogenes Laertius, Plutarch, and Stobœus, have with great preciſion tranſmitted to us their ideas And that this ſyſtem was no ſooner univerſally received, ought entirely be aſcribed to the force of prejudice; which, deciding every thing by appearances, prefers ſenſe to reaſon, and abandons whatever is not conformable to the judgment of the former.

3. Pythagoras thought the earth was a moveable body, and, ſo far from being the centre of the world, performed its revolutions around the region of fire, that is, the ſun, and thereby formed day and night. It is ſaid he obtained this knowledge among the Egyptians, who repreſented the ſun emblematically by a beetle, becauſe that inſect keeps itſelf ſix months under ground,

ground, and fix above; or, rather because having formed its dung into a ball, it afterwards lays itself on its back, and, by means of its feet, whirls that ball round in a circle.

4. Some impute this opinion to Philolaüs, the disciple of Pythagoras; but it is evident, he had the merit only of being the publisher of it, and several other opinions belonging to that school: for Eusebius expressly affirms, that he was the first who put Pythagoras's system into writing. Philolaüs added, that the earth moved in an oblique circle; by which, no doubt, he meant the zodiac.

5. Aristarchus of Samos, who lived about three centuries before Jesus Christ, was one of the principal defenders of the doctrine of the earth's motion. Archimedes, in his book, de Arenario, informs us, "That Aristarchus, writing on this subject against some of the philosophers of his own age, placed the sun immoveable in the center of an orbit, described by the earth in its circuit. And Sextus Empiricus also cites him as one of the principal supporters of this opinion. There is also a passage in Plutarch, whereby it appears, that Cleanthes accused Aristarchus of impiety, in troubling the repose of Vesta, and all the Larian gods; when, in giving an account of the phenomena of the planets in their courses, he taught that Heaven, or the firmament of the fixed stars, was immoveable: and that the earth moved in an oblique circle, revolving at the same time around its own axis.

6. Theophrastus, as quoted by Plutarch, says, in his History of Astronomy, which hath not reached our times, that Plato, when advanced in years, gave up the error he had been in, of making the sun turn round the earth; and lamented, that he had not placed it in the centre; but put the earth there, contrary to the order of nature. Nor is it at all strange, that Plato should re-assume an opinion which he had early imbibed in the schools of the two celebrated Pythagoreans, Archytas of Tarentum, and Timeus the Locrian; as

we

we ſee in St. Jerom's Chriſtian Apology againſt Ruſinus; and in Cicero we ſee, that Heraclides of Pontus, who was a Pythagorean, taught the ſame doctrine.

7. That the Earth is round, and inhabited on all ſides, and of courſe that there are Antipodes, or thoſe whoſe feet are directly oppoſite to ours, is one of the moſt ancient doctrines inculcated by philoſophy. Diogenes Laertius ſays, that Plato was the firſt who called the inhabitants of the earth oppoſite to us, Antipodes. He does not mean, that Plato was the firſt who taught this opinion, but only the firſt who made uſe of the term Antipodes; for, in another place, he mentions Pythagoras as the firſt who taught it. There is alſo a paſſage in Plutarch, whereby it appears, that it was a point of controverſy in his time: and Lucretius and Pliny, who oppoſe this notion, as well as St. Auguſtine, all ſerve as witneſſes that it muſt have prevailed in their time.

8. I make no mention of the condemnation of Biſhop Virgilius by Pope Zachary, for having taught this doctrine, becauſe it is a miſtake: the Pope, in that letter of his to St. Boniface, ſpeaks only of thoſe who maintained, that there was another world beſides this of ours, another ſun, another moon, and ſo on.

9. As to the proofs which the Ancients brought of the ſphericity of the earth, they were the very ſame that the moderns make uſe of. Pliny on this ſubject obſerves, that the land which retires out of ſight to perſons on the deck of a ſhip, appears ſtill in view to thoſe who are upon the maſt; and thence concludes that the earth is round. Ariſtotle drew this conſequence not only from the ſhadow of the earth's being circular on the diſk of the moon in the time of an eclipſe, but alſo from this circumſtance, that in travelling ſouth, we diſcover other ſtars, and that thoſe which we ſaw before, whether in the zenith, or elſewhere, change their ſituation with reſpect to us.

CHAP. XV.

Of the Revolution of the Planets about their own Axis.

1. HOW uſeful an aid the invention of teleſcopes hath been to the aſtronomical obſervations of the moderns, is particularly evident from their diſcovery, that the planets revolve on their axis; a diſcovery founded on the periodical revolution of the ſpots obſerved on their diſks: ſo that every planet performs two revolutions, by the one of which it is carried with others about a common centre; and by the other moves upon its axis round its own. But all that the moderns have advanced in this reſpect, ſerves only to confirm to the Ancients, the glory of being the firſt diſcoverers. The Moderns are in this to the Ancients, as the French philoſophers are to Sir Iſaac Newton, all whoſe labours and travels in viſiting the poles and equator to determine the figure of the earth, ſerve only to confirm what Sir Iſaac had thought of it, without ſo much as ſtirring from his cloſet. In the ſame manner, we have proved, that moſt of our experiments have ſerved, and do ſtill contribute to confirm and ſupport the conjectures of the Ancients; although it hath often happened, that thoſe very conjectures of theirs, which are now ſo generally received as true, have formerly been as generally decried. Of this we have had inſtances in the preceding chapter, and the preſent will exhibit another not leſs remarkable.

2. Whatever were the arguments upon which the Ancients founded their theory, certain it is, they clearly apprehended, that the planets revolved upon their own axis. Heraclides of Pontus, and Ecphantus, two celebrated Pythagoreans, intimated this truth long ago, and

and made uſe of a very apt compariſon to convey their idea, ſaying, that the earth turned from weſt to eaſt, juſt as a wheel does upon its axis, or centre. And Plato extended this obſervation from the earth to the other planets; for, according to Atticus, the Platonic, who explains his opinion, "To that general motion which makes the planets deſcribe a circular courſe, he added another reſulting from their ſpherical ſhape, which made each of them move about its own centre, whilſt they performed the general revolution of their courſe." Plotinus alſo aſcribes this ſentiment to Plato, for ſpeaking of him he ſays, that beſides the grand circular courſe obſerved by all the ſtars in general, he thought they each performed another about their own centre.

3. Cicero aſcribes the ſame notion to Nicetas of Syracuſe, and quotes Theophraſtus to warrant what he advances; this is he whom Diogenes Laertius names Hycetas, whoſe opinion was, that the celerity of the earth's motion about its own axis, and otherwiſe, was the only cauſe of the apparent revolutions of the Heavenly Bodies.

4. Our ſecondary planet, the moon, gave the Ancients an opportunity of diſplaying their penetration. They early diſcovered, that it had no light of its own, but ſhone with that which it reflected from the ſun. This, after Thales, was the ſentiment of Anaxagoras and of Empedocles, who thence accounted not only for the mildneſs of its ſplendor, but the imperceptibility of its heat; which our experiments confirm: for with all the aid of burning glaſſes, we have never yet found it practicable to produce the leaſt effect of heat from any combination of its rays.

5. The obſervations made by the moderns, tend to perſuade us, that the moon has an atmoſphere, though very rare. In a total eclipſe of the ſun, there appears about the diſk of the moon, a glimmering radiance, parallel to its circumference, which becomes more and more extenuated, or rare, as it diverges from it.

it. This, perhaps, is no other than an effect proceeding from ſuch a fluid as air; which by reaſon of its weight and elaſticity, is rather more denſe at bottom than at top. With a teleſcope we eaſily diſcern in the moon, parts more elevated, and more bright than others, which are judged to be mountains. We diſcern alſo other parts lower and leſs bright, which ſeem to be vallies lying between thoſe mountains. And there are other parts, which reflecting leſs light, and preſenting one uniform ſmooth ſurface, are ſuppoſed to be large pieces of water. If the moon then has its collections of water, its atmoſphere, its mountains, and its vallies; it is thence inferred, that there may alſo be rain there, and ſnow, and all the other aërial commotions natural to ſuch a ſituation; and our idea of the Wiſdom and Power of God, intimates to us, that he may have placed creatures there to inhabit it; rather than that all this diſplay of his ſkill, ſhould be a mere waſte.

6. The Ancients, who had not the aid of teleſcopes, ſupplied the defect of that inſtrument by a vivacity of penetration; for without the means that we have, they have deduced all thoſe conſequences that are admitted by the moderns: and diſcovered long before by the mental eye, whatever hath ſince been preſented to corporeal ſight through the medium of teleſcopes.

7. We ſee, by ſome fragments of theirs in how ſublime a manner, and worthy of the majeſty of the Deity, they entered into the views of that Supreme Being in his deſtination of the planets, and that multitude of ſtars placed by him in the firmament. They looked upon them as ſo many ſuns, about which rolled planets of their own, ſuch as thoſe of our ſolar ſyſtem. Nay, they went farther, maintaining that thoſe planets contained inhabitants, whoſe natures they preſume not to deſcribe, though they ſuppoſe them to yield to thoſe of ours, neither in beauty nor in dignity. Orpheus is the moſt ancient author, whoſe opinion on this ſubject hath come down to us. Proclus preſents us with three verſes of that ancient philoſopher, wherein he poſitively

aſſerts,

aſſerts, that the moon was another earth, having in it mountains, vallies, &c.

8. Pythagoras, who followed Orpheus in many of his opinions, taught, likewiſe, that the moon was an earth like ours, replete with animals, whoſe nature he preſumed not to deſcribe, though he was perſuaded, they were of a more noble and elegant kind than ours, and not liable to the ſame infirmities.

9. It were eaſy here to multiply quotations, and ſhow by a crowd of paſſages, that this opinion was very common among the ancient philoſophers; but I ſhall content myſelf with adding a remarkable paſſage of Stobœus, wherein he gives us Democritus's opinion about the nature of the moon, and the cauſe of thoſe ſpots which we ſee upon its diſk. That great philoſopher imagined, that thoſe ſpots were no other than ſhades, formed by the exceſſive heat of the lunar mountains, which intercepted the light from the lower parts of that planet, where the vallies formed themſelves into what appeared to us as ſhades or ſpots. Plutarch went farther, alledging, that there were emboſomed in the moon, vaſt ſeas, and profound caverns. Theſe, he conjectures, are built upon the ſame foundation with thoſe of the moderns: for, ſays he, thoſe deep and extenſive ſhades which appear upon the diſk of that planet, muſt be occaſioned by the vaſt ſeas it contains, which are incapable of reflecting ſo vivid a light, as the more ſolid and opaque parts; or by caverns extremely wide and deep, wherein the rays of the ſun are abſorbed, whence thoſe ſhades and that obſcurity which we call the ſpots of the moon. And Xenophanes ſaid, that thoſe immenſe cavities were inhabited by another race of men, who lived there, juſt as we do upon earth.

10. Yet it appears from one place in Plutarch, that in his time, as well as of late, it was diſputed by many, whether the moon yielded any exhalations or vapours for the production of rain, and the other meteors. He took part with thoſe who held the negative, being perſuaded

ſuaded that the moon muſt be ſo intenſely heated by the never-ceaſing action of the ſun's rays upon it, that all its humidity muſt be dried up, ſo as to render it incapable of furniſhing new vapours; whence he concludes, that there exiſted there, neither clouds, nor rains, nor winds; and of courſe neither plants nor animals. Now, this is the very reaſon alledged by ſuch of the moderns as oppoſe the notion of the moon's being inhabited; whereas the only neceſſary conſequence is, that the inhabitants of that planet muſt be entirely different from thoſe of ours, and by their conſtitution fitted to ſuch a clime, and ſuch a habitation. But however this be, it appears from this paſſage, that the opinion here mentioned, had partizans even in Plutarch's time, who were no leſs fertile than we are in conjectures to ſupport it.

CHAP. XVI.

The Milky Way; Solar Systems, or a Plurality of Worlds.

1. THAT lucid, whitiſh zone, which is ſeen in the firmament among the fixed ſtars, muſt have for a long while attracted the attention of the ancients, and occaſioned them to advance a great many conjectures about the reaſon of it, and among the various opinions reſpecting it, many without doubt, muſt to us appear groundleſs, ſince one only can be true. But this kind of deficiency is, what will befal genius in every age, however bright, and eſpecially thoſe who appeared in remote ages. A courſe of centuries ſo familiarizes the diſcovery of any truth, after it hath gained the general conſent, that we are aſtoniſhed, men of real ability, ſhould ever have heſitated about things which we have known from our infancy; and

we

we never give ourſelves the trouble to think, that the day perhaps ſhall come, when the ideas of Locke and Leibnits, and thoſe of the Newtonians, reſpecting attraction, and of our other naturaliſts upon other ſubjects, will be regarded by poſterity, as things ſo obvious, that they will be amazed, how ſuch great men could for any time reſiſt ſuch evidence. Should any one of us appear to them to have diſcerned the truth, in thoſe points which are at preſent in debate, how many of us will ſeem to have advanced nothing but reveries: and it will be happy, if, among ſuch a variety of opinions, ſome be found to be true; for it is no inconſiderable thing among men, when at great intervals, ſome one or other ariſes among them, who, with ſure ſteps ſo advances, as to keep clear of thoſe devious paths wherein others had wandered. This hath frequently happened among the moderns, and ſo it alſo did among the ancients. Truth often beamed through the obſcurity in which their knowledge was enveloped. Many erred in their conjectures, whilſt only one or two diſcovered the right courſe, and pointed it out to others; ſo we, of this age, direct our views by the beams of thoſe geniuſes who have illuminated it.

2. The milky way, and fixed ſtars, have been an object of inquiry to many philoſophers. As to the former of theſe, the Pythagoreans held that it had once been the ſun's path, and that he had left in it that trace of white, which we now obſerve there. The Peripatetics have aſſerted, after Ariſtotle, that it was formed of exhalations, ſuſpended high in air. I eaſily admit, that there were miſtakes; but all were not miſtaken in their conjectures. Democritus, without the aid of a teleſcope, preceded Galileo in remarking, that what we call the milky way, contained in it an innumerable quantity of fixed ſtars, the mixture of whoſe diſtant rays occaſioned the whiteneſs which we thus denominate: or to expreſs it in Plutarch's words, it was the united brightneſs of an immenſe number of ſtars.

3. The

3. The ancients were no leſs clear in their conceptions of the nature of the fixed ſtars than we are: for it is but a ſhort while ago, that the moderns adopted the ideas of thoſe great maſters on this ſubject, after having rejected them during many ages. It would be reckoned an abſurdity in philoſophy at preſent, to doubt of thoſe ſtars being ſuns like ours, each reſpectively having planets of their own, which revolve around them, and form various ſolar ſyſtems, more or leſs reſembling that of ours. All philoſophers at preſent, admit of this theory; and even leſs philoſophic minds, begin to render this conception familiar to them, thanks to the elegant work of Mr. de Fontenelle.

4. And this notion of a plurality of worlds, was generally inculcated by the Grecian philoſophers. Plutarch, after having given an account of it, ſays, "That he was ſo far from finding fault with it, that he thought it highly probable there had been, and were, like this of ours, an innumerable, though not abſolutely infinite multitude of worlds; wherein were, as well as here, land and water, inveſted by ſky."

5. Anaximenes was one of the firſt who taught this doctrine. He believed, that the ſtars were immenſe maſſes of fire, around which certain terreſtrial globes, imperceptible to us, accompliſhed their periodic revolutions. It is evident, that by theſe terreſtrial globes, turning round thoſe maſſes of fire, he meant planets, ſuch as ours, ſubordinate to their own ſun, and forming along with him a ſolar ſyſtem.

6. Anaximenes agreed with Thales in this opinion, which paſſed from the Ionic to the Italic ſect; who held, that every ſtar was a world, containing in itſelf a ſun and planets, all fixed in that immenſe ſpace, which they called ether.

7. Heraclides, and all the Pythagoreans taught the ſame, that every ſtar was a world, or ſolar ſyſtem, having, like this of ours, its ſun and planets, inveſted with

with an atmoſphere of air, and moving in the fluid ether, by which they were ſuſtained. This opinion ſeems to have been of ſtill more ancient origin. We find traces of it in the verſes of Orpheus, who lived in the time of the Trojan War, and taught that there was a plurality of worlds; a doctrine which Epicurus alſo looked upon as very probable.

8. Origen, in his Philoſophumena, treats amply of the opinion of Democritus, ſaying, "That he taught, that there was an innumerable multitude of worlds, of unequal ſize, and differing in the number of their planets; that ſome of them were as large as ours, and placed at unequal diſtances; that ſome were inhabited by animals, which he could not take upon him to deſcribe: and that ſome had neither animals, nor plants, nor any thing like what appeared among us." For that truly philoſophic genius diſcerned, that the different nature of thoſe ſpheres required inhabitants of very different kinds.

9. It appears, that Ariſtotle alſo held this opinion, as did likewiſe Alcinoüs, the Platonic, and Lewis Cœlius de Rovigo, aſcribes it to Plotinus; who held beſides, that the earth, compared to the reſt of the univerſe, was one of the meaneſt globes in it.

10. It was certainly, in conſequence of ſuch an idea, that Phavorinus ſtruck out into that remarkable conjecture of his, of the exiſtence of other planets, beſides thoſe known to us. "He was aſtoniſhed how it came to be admitted as certain, that there were no other wandering ſtars, or planets, but thoſe obſerved by the Chaldeans. As for his part, he taught that there number was more conſiderable than was vulgarly given out, though they had hitherto eſcaped our notice." Here in all likelihood he alludes to the reality of thoſe ſatellites, which have ſince become manifeſt by means of the teleſcope. It required ſingular penetration to be capable of forming this ſuppoſition, and of having, as it were predicted this diſcovery. Seneca makes mention of a ſimilar notion of Democritus; who

who, in a treatiſe which he wrote concerning the planets, of which only the title has been handed down to us, ſuppoſe that there were many more of them, than had yet come within our view; though he ſays nothing either of their names or magnitude.

CHAP. XVII.

Of Comets.

1. THERE is no extravagance of fancy, how wild ſoever, but what hath been hazarded in different ages, to account for the nature of comets, and the irregularity of their courſe. Even in the laſt age, Kepler and Hevelius advanced conjectures entirely extravagant reſpecting the cauſe of theſe phenomena. Mr. Caſſini, and after him Sir Iſaac Newton, have at length given certainty to the opinions of the philoſophers in this reſpect, by obſervations and calculations moſt juſt and accurate; or, to ſpeak with more propriety, by recalling and fixing our attention upon what had formerly been advanced by the Chaldeans, Egyptians, Anaxagoras, Democritus, Pythagoras Hippocrates of Chois, Seneca, Apollonius Myndius, and Artemidorus. For, in treating of the nature of theſe ſtars, their definitions of them, the reaſons they aſſign for the rareneſs of their appearance, and the apologies they make for not having yet formed a more exact theory, are all in the very terms that Seneca had already uſed. With reſpect to the time of that philoſopher, we have formerly taken notice, that the collecting together the obſervations anciently made of the returns of comets, was not ſufficient to eſtabliſh the theory of them; becauſe, their appearances were ſo very rare, that there had not been an opportunity of making a proper number of obſervations, to determine whether

their courſe was regular or not; but that the Greeks, who had ſome time before obſerved this, were applying themſelves to reſearches of this kind.

2. Seneca, in the ſame place, acquaints us, that the Chaldeans looked upon comets as planetary bodies; and Diodorus Siculus, in his hiſtory, giving an account of the extent of knowledge among the Egyptians, praiſes them for the application with which they ſtudied the ſtars and their courſes: where he remarks, that they had collected obſervations very ancient and very exact, fully informing them of the ſeveral motions, orbits, and ſtations of the planets; adding alſo, that they could foretel earthquakes, inundations, and the return of comets.

3. Ariſtotle, in laying down the opinion of Anaxagoras and Democritus, ſays of the firſt, that he apprehended comets to be an aſſemblage of many wandering ſtars; which, by their approximation, and the mutual blending of their rays, rendered themſelves viſible to us. This notion was far from being philoſophical, yet was it preferable to that of ſome great moderns, ſuch as Kepler and Hevelius, who would have it, that they were formed out of air, as fiſhes are out of water. Pythagoras, who approached very near to the times of Anaxagoras, taught, according to Ariſtotle's account, an opinion worthy of the moſt enlightened age; for he looked upon comets as ſtars, which circulated regularly, though elliptically about the ſun, and which appeared to us only in particular parts of their orbit, and at conſiderable diſtances of time; and the error which Ariſtotle falls into, in endeavouring to explain Pythagoras's ſentiment, by a compariſon referring to the planet Mercury, ought not to be imputed to the Pythagoric ſchool. Ariſtotle relates alſo the teſtimonies of Hippocrates of Chois, and Æſchylus, in confirmation of this opinion.

4. Stobœus preſents us with Pythagoras's ſentiment in the very terms of Ariſtotle, though ſomewhat more clearly; for he ſays, they imagined the comets to be wandering

wandering planets, which appeared only at certain times during their courſe.

5. Upon the whole, Seneca, more than any other, hath diſcuſſed this ſubject like a true philoſopher. In his ſeventh book of natural queſtions, he relates all the different opinions reſpecting comets, and ſeems to prefer that of Artemidorus, who imagined, "that there was an immenſe number of them, but that their orbits were ſo ſituated, that, ſo far from being always within view, they could only be ſeen at one of the extremities." He afterwards reaſons upon this with equal elegance and ſolidity. "Why ſhould we be aſtoniſhed, ſays he, that comets, which are ſo rare a ſpectacle in the world, have not yet come under certain rules; or that we have not hitherto been able to determine, where begins or ends the courſe of planets, as ancient as the univerſe, and whoſe returns are at ſuch diſtant intervals? The time will come, cries he, that poſterity will be amazed at our ignorance in things ſo very evident; for what now appears to us obſcure, will one day or other, in the courſe of ages, and through the induſtry of our deſcendants, become manifeſtly clear; but a ſmall number of years, paſſed between ſtudy and the indulgence of paſſion, will not avail for reſearches ſo important, as thoſe which propoſe to themſelves the compreſſion of natures ſo remote."

6. Upon a review of the ſeveral paſſages which we have juſt now cited, it muſt now be admitted, that the moderns have ſaid nothing ſolid with regard to comets, but what is to be found in the writings of the ancients; except what later obſervations have furniſhed them with, which Seneca judged to be ſo neceſſary, and which only can be the effect of a long ſucceſſion of ages.

CHAP. XVIII.

Of the Refraction of Light, and Aſtronomical Refraction; and of Perſpective.

1. THE Arabians applied themſelves with much aſſiduity to the ſtudy of the ſciences, and the ſituation of their climate led them to prefer aſtronomy, which they cultivated very early. There are a conſiderable quantity of their writings in our large repoſitories for books, which have never yet come under our notice, having ſtill remained in manuſcript in their original language: ſo great has been our neglect of them for ſome ages. Yet thoſe who have been at the pains curiouſly to ranſack thoſe manuſcripts, have been well rewarded for their trouble, by the acquiſition they have thence made of many new and original ideas, and the information they have received of various inventions and diſcoveries, uſeful and entertaining. A learned gentleman at Oxford, who carefully examined the Arabian manuſcripts in the famous library of that univerſity, gives his ſanction to this in a manner that ſhould engage others to imitate his example in ſuch reſearches. Among other motives naturally tending to produce this effect, he ſays; "The advantages recommending the ſtudy of aſtronomy to the people of the eaſt were many. The ſerenity of their weather; the largeneſs and correctneſs of the inſtruments they made uſe of, much exceeding what the moderns would be willing to believe; the multitude of their obſervations and writings being ſix times more than what have been compoſed by Greeks and Latins; and, in ſhort, the number of powerful princes, who, in a manner becoming their own magnificence, aided them with protection.

tion. "One letter is not ſufficient," ſays he, "to ſhew in how many reſpects the Arabian aſtronomers detected the deficiency of Ptolomy, and the pains they took to correct him; how carefully they meaſured time by water-clocks, ſand-glaſſes, immenſe ſolar dials, and even what perhaps will ſurpriſe you, the vibrations of the pendulum; and with what aſſiduity and accuracy they conducted themſelves in thoſe nice attempts, which do ſo much honour to human genius in the taking the diſtances of the ſtars, and the meaſure of the earth."

2. Hence it is manifeſt that the vibration of the pendulum was employed by the ancient Arabians, long before the epocha we ordinarily aſſign for its firſt diſcovery; and the uſe it was applied to, was exactly to meaſure time, the very purpoſe for which we employ it.

3. The diſcovery of the refraction of light, is of more ancient origin than is generally imagined; for the cauſe of it appears to have been known to Ptolomy. According to Roger Bacon's account, that great philoſopher and geometrician gave the ſame explanation of that phenomenon, which Deſcartes has done ſince; for he ſays, "that a ray, paſſing from a more rare into a more denſe medium, becomes more perpendicular." Ptolomy wrote a treatiſe on optics, which was extant in Bacon's time; and Alhazen ſeems not only to have known that treatiſe of Ptolomy, but to have drawn thence whatever is truly eſtimated in what he advances about the refraction of light, aſtronomical refraction, and the cauſe of the extraordinary ſize of planets when they appear on the horizon. This laſt point, diſcuſſed with ſo much warmth between Mallebranche and Regis, had already been adjuſted by Ptolomy.

4. Ptolomy, and after him Alhazen, ſaid, that "when a ray of light paſſes from a more rare, into a more denſe medium, it changes its direction when it arrives upon the ſurface of the latter, deſcribing a line which

which interſects the angle made by that of its firſt direction, and a perpendicular falling upon it from the more denſe medium." Bacon adds, after Ptolomy, that "the angle formed by the coincidence of thoſe two lines, is not always equally divided by the refracted ray; becauſe in proportion to the greater or leſs denſity of the medium, the ray is more or leſs refracted, or obliged to decline from its firſt direction." In this he approaches very near to the reaſon aſſigned by Sir Iſaac Newton, who deducing the cauſe of refraction, from the attraction made upon the ray of light by the bodies ſurrounding it, ſays, "that mediums are more or leſs attractive in proportion to their denſity."

5. Ptolomy, acquainted with the principle of the refraction of light, could not fail to conclude, that this was the cauſe alſo of what was called aſtronomic refraction, or of the appearance of planets upon the horizon before they came there; having recourſe therefore to this principle, he accounted for thoſe appearances from the difference there was between the medium of air, and that of ether which lay beyond it; ſo that the rays of light coming from the planet, and entering into the denſer medium of our atmoſphere, muſt of courſe be ſo attracted as to change their direction, and by that means bring the ſtar to our view, before it really came upon the horizon. Alhazen tells us of a method whereby we may aſſure ourſelves of this truth by obſervation. "He bids us take an armillary ſphere, and upon it meaſure the diſtance of any ſtar from the pole, when it paſſes neareſt its zenith under the meridian, and when it appears on the horizon." "This laſt," he ſays, "will be its ſmalleſt diſtance." He then makes it appear, that refraction is the cauſe of this phenomenon. Yet Alhazen advances nothing but what he derived from Ptolomy; and neither one nor other of them have applied this important diſcovery in aſtronomy, ſo as to deduce from it, that the apparent elevation of the ſtars, when near the horizon, neceſſarily requires to be corrected.

6. Roger

6. Roger Bacon, enquiring into the cauſe of that difference of magnitude in ſtars when ſeen on the horizon, from what they have when viewed over head, ſays, in the firſt place, that it may proceed from this, "That the rays coming from the ſtar are made to diverge from each other, not only by paſſing from the rare medium of ether into the denſer one of our ſurrounding air, but alſo by the interpoſition of clouds and vapours ariſing out of the earth, which repeat the refraction and augment the diſperſion of the rays, whereby the object muſt needs be magnified to our eye." "Though, ſays he afterwards, there has been aſſigned by Ptolomy and Alhazen another cauſe for this; theſe authors thought that the reaſon of a ſtar's appearing larger at its riſing or ſetting than when viewed over head, aroſe from this, that when the ſtar is over head, there are no immediate objects perceived between it and us, ſo that we judged it nearer to us, and are not ſurpriſed at its littleneſs; but when a ſtar is viewed on the horizon, it lies then ſo low, that all we can ſee upon earth, interpoſes between it and us, which making it appear at a greater diſtance, we imagine it larger than it is. For the ſame reaſon the ſun and moon, when appearing upon the horizon, ſeem to be at a greater diſtance by reaſon of the interpoſition of thoſe objects which are upon the ſurface of our earth, than when they are over head; and conſequently there will ariſe in our minds an idea of their largeneſs, augmented by that of their diſtance, and this of courſe muſt make it appear larger to us when viewed on the horizon, than when ſeen in the zenith."

7. Moſt of the learned deny the ancients the advantage of having known the rules of perſpective, or of having put them in practice; although Vitruvius makes mention of the principles of Democritus and Anaxagoras reſpecting that ſcience, in a manner that plainly ſhows they were not ignorant of them. "Anaxagoras and Democritus, ſays he, were inſtructed by Agatarchus the diſciple of Æſcylus. They both of them taught the rules of drawing, ſo as to imitate from any point of view the proſpect that lay in ſight, by making

making the lines in their draught, iſſuing from the point of view there, exactly reſemble the radiation of thoſe in nature; inſomuch that, however ignorant any one might be of the rules whereby this was performed, yet they could not but know at ſight the edifices, and other proſpects which offered themſelves in the perſpective ſcenes they drew for the decoration of the theatre; where, though all the objects were repreſented on a plain ſurface, yet they ſwelled out, or retired from the ſight, juſt as objects do endowed with all dimenſions." Again he ſays, "that the painter Apatarius drew a ſcene for the theatre at Tralles, which was wonderfully pleaſing to the eye, on account that the artiſt had ſo well managed the lights and ſhades, that the architecture appeared in reality to have all its projections." Plato, in two or three places of his dialogues, ſpeaks in ſuch a manner of the effects of perſpective, as makes it evident that he was acquainted with its principles. Pliny ſays, "that Pamphilus, who was an excellent painter, applied himſelf much to the ſtudy of geometry, and maintained that, without its aid, it was impoſſible ever to arrive at perfection in that art;" which holds certainly true with reſpect to perſpective. And a little farther he uſes an expreſſion, which can allude to nothing but perſpective; when he ſays, "that Apelles fell ſhort of Aſclepiodorus in the art of laying down diſtances in his paintings." Lucian, in his dialogue of Zeuxis, ſpeaks of the effects of perſpective in pictures. Philoſtratus, in his preface to his drawings, or hiſtory of painting, makes it appear that he knew this ſcience; and in the deſcription he gives of Menœtius's picture of the ſiege of Thebes, he places full in ſight the happy effects of perſpective when ſtudied with care. There he extols the genius of this painter, who, in repreſenting the walls of the place inveſted, and ſcaled by ſoldiers, placed ſome of them full in view, others to be ſeen only as far as the knee, others only at half length, and others whoſe heads only, or helmets, were ſeen, till the whole ended in the points of the ſpears of thoſe who were not ſeen at all; and he adds, that all this was the effect of perſpective, which deceives the eye by means of the flexure of its lines,

which

which gradually approaching one another as they ſeem to recede from view, proportionally diminiſh the encloſed objects, and make them appear to retire.

8. Ariſtotle was the firſt who propoſed the famous problem, reſpecting the roundneſs of that image of the ſun, which is formed by his rays paſſing through a ſmall puncture, even though the hole itſelf be ſquare or triangular. Marolle, reſolved this about the middle of the fifteenth century, by demonſtrating that this puncture is the vertex of two cones of light, the one of which has the ſun itſelf for its baſe, and the other the refracted image. Upon this Mr. de Montucla aſcribes to him the whole honour of the ſolution of this optical problem, formerly indeed propoſed by ariſtotle, but which that ancient philoſopher, ſays he, according to his wonted way, had but badly accounted for. It is with regret that I find myſelf obliged to animadvert upon ſome very material miſtakes, into which Mr. de Montucla has ſlipt, whoſe judgment I ſo much revere on other occaſions. For firſt of all, from his manner of quoting this problem of Ariſtotle, it appears that he neither conſulted the Greek text, nor even the Latin verſion that accompanies it: inſomuch that I am quite at a loſs to conceive where he came by this problem of Ariſtotle, as he produces it; and ſtill more, where he met with this obſcure ſolution of it, which he imputes to that ancient philoſopher. Ariſtotle's only inquiry is, why the ſun, in tranſmitting his beams through a ſquare puncture, does not form a rectilineal figure? And Mr. de Montucla, inſtead of this, makes him ſubſtitute quite another queſtion, reſpecting the ſun in a partial eclipſe: why his rays, in paſſing through ſuch a puncture, ſhould produce a figure exactly reſembling that part of his diſk, which remains yet unobſcured? But of all this there is not one word in Ariſtotle. Mr. de Montucla afterwards affirms, that this queſtion, the proper ſolution of which had till then been diſpaired of by naturaliſts, reduced them all to the neceſſity of ſaying with Ariſtotle, that light naturally threw itſelf into a round form or aſſumed the reſemblance of the luminous body, as ſoon as ever it had ſurmounted the obſta-

cle which put it under conſtraint. Now this again is what Ariſtotle ſays nothing at all of. He gives two ſolutions of his own problem: the firſt of which is certainly the foundation, if not the entire ſubſtance, of what Mr, de Montucla calls the diſcovery of Marolle. To enable the reader to decide, whether I have wronged Mr. de Montucla, I preſent him with a literal tranſlation of a paſſage of Ariſtotle's, containing in it his firſt ſolution of this problem. "Why is it that the ſun, in paſſing through a ſquare puncture, forms itſelf into an orbicular, and not into a rectilineal figure, as when it ſhines through a grate? Is it not becauſe the efflux of its rays, through the puncture, converges it into a cone whoſe baſe is the luminous circle?" This may ſerve to confirm, what I have formerly ventured to aſſert, that we but ſeldom do juſtice enough to the ancients, either through our entire neglect of them, or from not rightly underſtanding them.

CHAP. XIX.

Of the many Discoveries of the Ancients in Mathematics, &c.

1. A Large book might be compoſed, were we but curſorily to mention all the important diſcoveries in geometry, mathematics, and philoſophy, for which we are indebted to the ancients. Wherefore, not to ſwell this volume we ſhall juſt point at the principal of them, without inſiſting at length; becauſe it is generally acknowledged that they owe their origin to thoſe philoſophers of antiquity.

2. All the learned agree, that Thales was the firſt we know of, who predicted eclipſes; pointed out the advantages that muſt ariſe from a due obſervation of the little bear, or polar ſtar; taught that the earth was

was round, and the ecliptic in an oblique poſition. He did no leſs ſervice to geometry than aſtronomy. He inſtructed in that ſcience the Egyptians themſelves, to whom he went to be taught. He ſhewed them how to meaſure the pyramids by the length of their ſhades, and to determine the meaſure of inacceſſible heights and diaſtnces, by the proportion of the ſides of a triangle. He demonſtrated the various properties of the circle; particularly that whereby it appears, that all triangles which have the diameter for their baſe, the ſubtending angle of which touches the circumference, are in that point of contact right-angled. He diſcovered reſpecting the iſoſceles triangle, that the angles at its baſe were equal; and was the firſt who found out, that in right lines cutting one another, the oppoſite angles are equal. In ſhort, he taught a great many other valuable truths, too long to be narrated. We owe to Anaximander, the ſucceſſor of Thales, the invention of the armillary ſphere, and of ſun-dials; he was likewiſe the firſt who drew a geographical map.

3. Pythagoras has already afforded to us many inſtances of his profound knowledge in all the ſciences. There are few philoſophers, even among the ancients, who had ſo much ſagacity and depth of genius. He was the firſt who gave ſure and fundamental precepts with reſpect to muſic, which he fixed upon by a reach of diſcernment that was extraordinary. Struck by the difference of ſounds which iſſued from the hammers of a forge, but came into uniſon at the fourth, and fifth, and eight percuſſions; he concluded that this muſt proceed from the difference of weight in the hammers; he had them weighed, and found that he had conjectured right. Upon this he wound up ſome muſical ſtrings, in number equal to the hammers, and of a length proportioned to their weight; and found, that at the ſame intervals, they correſponded with the hammers in ſound. It was upon the ſame principle that he deviſed the monochord; an inſtrument conſiſting of one ſtring, yet capable of eaſily determining the various relations of ſound. He alſo made many fine diſcoveries in geometry, among others that property of a right-angled triangle,

triangle, that the ſquare of the hypothenuſe, or ſide ſubtending the right angle, is equal to the ſquares of the two other ſides. And he gave the firſt ſketch of the doctrine of iſoperimenters in demonſtrating, that of all plain figures, the circle is the largeſt; and of all ſolids, the ſphere.

4. Plato likewiſe applied himſelf to the ſtudy of mathematics; and we owe to him many fine diſcoveries in that ſcience. He it was, who firſt introduced the analytic method, or that geometric analyſis, which enables us to find the truth we are in queſt of, out of the propoſition itſelf which we want to reſolve. He it was who at length ſolved the famous problem, reſpecting the duplication of the cube, on account of which ſo much honour is paid, by all the philoſophers of his ſchool, to Euxodus, Archytus, and Menechmus. To him alſo is aſcribed the ſolution of the problem concerning the triſection of an angle; and the diſcovery of the conic ſections. Pappus hath given us the ſummary of a great many analytic works. In the preface to his ſeventh book, we meet with this principle of Guldinus, that whatever figure ariſes from the circumvolution of another, is produced by the revolution of the latter about its centre of gravity.

5. Geometry is indebted to Hipparchus for the firſt elements of plain and ſpherical trigonometry; and to Diophantes, who lived 360 years before Jeſus Chriſt, we owe the invention of algebra. That the ancients laid the firſt foundation of algebra, is a thing out of doubt, and ſhewn by the celebrated Wallis in his hiſtory of that ſcience. He makes no queſtion but algebra was known to the ancients, and that they thence drew thoſe long and difficult demonſtrations which we meet with in their works. He ſupports his opinion by the teſtimonies of Schoten, Oughtred, and Barrow; and makes mention of a manuſcript in the Savilian library, which treates of this ſcience and bears the name of Apollonius. But he thinks the ancients carefully concealed a method, which furniſhed them with ſo many beautiful and difficult demonſtrations; and that they

they chose rather to prove their propositions by reasonings ad absurdum, than to hazard the discovery of that method, which brough them more directly to the result of what they demonstrated. One to whom algebra is much indebted, Leibnits, forms the same judgment. Speaking of the higher operations of it, he says, "In perusing the arithmetic of Diophantes, and the geometrical books of Apollonius and Pappus, we cannot doubt but the ancients had some knowledge of it. Vietus extended it still further, in expressing by those general characters, not only unknown numbers and proportions, but such as are known; doing that by figures, which Euclid does by reasoning. And Descartes hath extended it to geometry, in marking by equations the proportions of lines. Yet, even since the discovery of our modern algebra, Mr. Bouillaud, whom I was acquainted with at Paris, and who was without all doubt an excellent geometrician, never could reflect, but with astonishment, on the demonstrations of Archimedes concerning the properties of the spiral line, and could not conceive how that great man hit upon the applying the tangent of that line to the commensuration of the circulation of the circle." Nunes is of the same opinion with the former; and in his history of algebra, regrets that the ancients concealed from us, a method which they themselves used; and says, "that we are not to think that the greater part of the propositions of Euclid and Archimedes, were founded by those great men in that way of reasoning, in which they have thought proper to transmit them to us."

6. This method of theirs, which resembled our algebra, sometimes however discovers itself in their researches. We meet with traces of it sufficiently strong in the thirteenth book of Euclid; especially if we make use of the Greek text, or the old Latin translation. And although Wallis imagines, that they may belong to some other scholiasts; yet the antiquity of the science itself will still be the same. Some indeed make it mount much higher, who, led by the authority of some able mathematicians among the ancients, assign the first invention of it to Plato. Whoever desires to enter into a more

a more exact examination of this, will find in Wallis a guide and monitor, whoſe authority may be acquieſced in, he having ſet this matter in the cleareſt light, as well as made the firſt and nobleſt efforts in our time, to raiſe algebra to the ſtate of perfection which it hath now attained. Now, according to this able geometrician, the method of inveſtigating infinite ſerieſes took its riſe from his arithmetic of infinites, publiſhed in 1656; and he himſelf acknowledges, that both of them are founded on the method of exhauſtions uſed by the ancients. He farther ſays, that the method of indiviſibles introduced by Cavallieri, is no other than an abridgement of that of exhauſtions, though ſomewhat more obſcure. He obſerves, that the lines and ſurfaces, whoſe proportion and contents are inquired into, and aſcertained by Cavallieri, differ in nothing from the inſcribed and circumſcribed triangles, whoſe approaches Archimedes brought ſo near, that the difference of the ſpace encloſed between them, and that which they approached, and about which they were drawn, to wit, the contents of the circle, might become leſs than any aſſignable quantity: and this he proves afterwards, by an analytic expoſition of both. I may however remark, that from the time of Diophantes, algebra made but ſmall progreſs, till that of Vietus, who reſtored and perfected it, and was the firſt who marked the known quantities by the letters of the alphabet.

7. Beſides the diſcoveries made in aſtronomy by the ancients, which we have been reading, there are a great many others, which I cannot bring into view, in that full manner they deſerve. Yet I cannot omit mentioning here one important obſervation of Ariſtarchus. He was the firſt who ſuggeſted a method of meaſuring the diſtance of the ſun from the earth, by means of the half ſection of the moon's diſk, or that phaſis of it wherein it appears to us when it is in its quadratures.

8. Hipparchus was the firſt who calculated tables of the motion of the ſun and moon, and compoſed a catalogue of the fixed ſtars. He was alſo the firſt, who, from the obſervation of eclipſes, determined the longitude

longitude of places upon earth; but what above all does immortal honour to his genius is, that he laid the firſt foundations for the diſcovery of the preceſſion of the equinoxes. Mr. Bayle reprehends Rohault as lying under a miſtake, when he ſays that "Hipparchus knew nothing of the peculiar motion of the fixed ſtars from weſt to eaſt, which is the cauſe of their varying the longitude." Yea, and Timœus Locrenſis, who lived before Plato, taught this very aſtronomical truth in clear terms.

CHAP. XX.

Of Archimedes; of the Mechanics and Architecture of the Ancients; and of Microscopes. Of Sculpture, Painting, and the Origin of Music.

1. ARCHIMEDES alone would afford ſufficient matter for a volume, in giving a detail of the marvellous diſcoveries of a genius ſo profound, and fertile in invention. We have ſeen, that ſome of his diſcoveries appeared ſo much above the reach of men, that many of the learned of our days found it more eaſy to call them in doubt, than even to imagine the means, whereby he had acquired them. We are again going to produce proofs of the fecundity of genius belonging to this celebrated man. Leibnits did juſtice to the genius of Archimedes, when he ſaid, that if we were better acquainted with the admirable productions of that great man, we would throw away much leſs of our applauſe on the diſcoveries of eminent moderns.

2. Wallis calls him a man of admirable ſagacity, who laid the foundation of almoſt all thoſe inventions, which our age glories in having brought to perfection.

In

In reality, what a glorious light hath been diffuſed over the mathematics, in his attempt to ſquare the circle, and in diſcovering the ſquare of the parabola, the properties of ſpiral lines, the proportion of the ſphere to the cylinder, and the true principles of ſtatics and hydroſtatics? What a proof of his ſagacity did he give in diſcovering the quantity of ſilver, that was mixed with the gold, in the crown of King Hiero; whilſt he reaſoned upon that principle, that all bodies immerged in water loſe juſt ſo much of their weight, as a quantity of water equal to them in bulk weighs? Hence he drew this conſequence, that gold being more compact muſt loſe leſs of its weight, and ſilver more; and that a mingled maſs of both muſt loſe, in proportion to the quantities mingled. Weighing therefore the crown in water and in air, and two maſſes, the one of gold, the other of ſilver, equal in weight to the crown; he thence determined what each loſt of their weight, and ſo reſolved the problem. He likewiſe invented a perpetual ſcrew, valuable on account of its being capable to overcome any reſiſtance; and the ſcrew, that ſtill goes by his name, uſed in elevating of water. He of himſelf alone defended the city of Syracuſe, by oppoſing to the efforts of a Roman general, the reſources he found in his own genius. By means of many various warlike machines, all of his own conſtruction, he rendered Syracuſe inacceſſible to the enemy. Sometimes he hurled upon their land forces ſtones of ſuch an enormous ſize, as cruſhed whole bodies of them at once, and put the whole army into confuſion. And when they retired from the walls, he ſtill found means to annoy them; for with his baliſtæ, he overwhelmed them with arrows innumerable, and beams of a prodigious weight. If their veſſels approached the fort, he ſeized them by the prows with grapples of iron, which he let down upon them from the walls; and rearing them up in the air, to the great aſtoniſhment of every one, ſhook them with ſuch violence, as either to break them in pieces, or ſink them to the bottom.

3. The ſuperior knowledge he had in ſciences, and his confidence in the powers of mechaniſm, prompted him

him once to ſay to King Hiero, who was his patron, admirer, and friend, "Give me where to ſtand, and I will move the earth." And when the king, amazed at what he ſaid, ſeemed to be in heſitation, he gave him a ſtriking proof of his ſkill, in launching, ſingly by himſelf, a ſhip of a prodigious weight. He built likewiſe for the king an immenſe gallery, of twenty banks of oars, containing ſpacious apartments, gardens, walks, ponds, and all other conveniences ſuitable to the dignity of a great king. He conſtructed alſo a ſphere repreſenting all the motions of the ſtars, which Cicero eſteemed one of the inventions, that did the higheſt honour to human genius. He perfected the manner of augmenting the mechanic powers, by the multiplication of wheels and pullies; and, in ſhort, carried mechanics ſo far, that the works he produced ſurpaſs imagination.

4. Nor was Archimedes the only one, who ſucceeded in mechanics. The immenſe machines, and of aſtoniſhing force, as were thoſe which the ancients adapted to the purpoſe of war, are a proof, they came nothing behind us in this reſpect. It is with difficulty we can conceive, how they reared thoſe bulky towers, a hundred and fifty-two feet in height, and ſixty in compaſs, aſcending by many ſtories, having at bottom a battering ram, a machine of ſtrength ſufficient to beat down walls; in the middle a draw-bridge, to be let down upon the wall of the city attacked, in order to open a paſſage into the town for the aſſailants; and at the top a body of men, who, being placed above the beſieged, haraſſed them without running any riſk. An ancient hiſtorian has tranſmitted to us an action of an engineer at Alexandria, which deſerves to have a place here. In defending that city, when it was attacked by Julius Cæſar, he, by means of wheels and other machines, drew from the ſea a prodigious quantity of water, which he turned upon the adverſary, to their extreme annoyance. Indeed the art of war gave occaſion for a great number of inſtances of this kind, which cannot but excite in us the higheſt idea of the enterprizing genius of the ancients, and the vigour wherewith they

put

put their deſigns in execution. The invention of pumps by Cteſibius, and that of water-clocks, cranes, automatical figures, and wind-machines by Heron, and the other diſcoveries of the Grecian geometricians, are ſo very numerous, that it would exceed the limits of a chapter, even to mention them.

5. Should we paſs to other conſiderations, we ſhould find equally inconteſtable evidences of greatneſs of genius among the ancients, in the difficult and indeed aſtoniſhing experiments, in which they ſo ſucceſsfully engaged. Egypt and Paleſtine ſtill preſent us with proofs of this, the one in its pyramids, the other in the ruins of Palmyra and Balbec.* Italy is filled with monuments, and the ruins of monuments, which aid us in comprehending the former magnificence of that people. And ancient Rome even now attracts much more of our admiration, than the modern.

6. The greateſt cities of Europe give but a faint idea of that grandeur, which all hiſtorians unanimouſly aſcribe to the famous city of Babylon; which, being fifteen leagues in circumference, was encompaſſed with walls two hundred feet in height, and fifty in breadth; whoſe ſides were adorned with gardens of a prodigious extent, which aroſe in terraſſes one above another, to the very ſummit of the walls. And for the watering of thoſe gardens, they had contrived machines, which raiſed the water of the Euphrates to the very higheſt of theſe terraſſes; a height equalling that, to which the water is carried by the machine at Marly. The tower at Belus, ariſing out of the middle of a temple, was of ſo vaſt a height, that ſome ancient authors have not ventured to aſſign the meaſure of it; others put it at a thouſand paces.

7. Ecbatane, the capital of Media, was of immenſe magnificence, being eight leagues in circumference,

* It is proper to remark, that the temples and immense palaces of Palmyra, whose magnificence surpasses all other buildings in the world, appear to have been built at the time, when architecture was in its decline.

and

and ſurrounded with ſeven walls in form of an amphitheatre; the battlements of which were of various colours, white, black, ſcarlet, blue, and orange; but all of them covered with ſilver or with gold. Perſepolis was alſo a city, which all hiſtorians ſpeak of as one of the moſt ancient and noble of Aſia. There remain the ruins of one of its palaces, which meaſured ſix hundred paces in front, and ſtill diſplays the relics of its ancient grandeur.

8. The lake Mocris is likewiſe a ſtriking proof of the vaſt undertakings of the ancients. All hiſtorians agree in giving it above a hundred and fifty leagues in circuit: yet was it entirely the work of one Egyptian king, who cauſed that immenſe compaſs of ground to be hollowed, to receive the waters of the Nile, when it overflowed more than ordinary, and to ſerve as a reſervoir for watering Egypt by means of its canals, when the overflowing of the river was not of height ſufficient to enrich the country. Out of the midſt of this lake aroſe two pyramids, of about ſix hundred feet in height.

9. The other pyramids of Egypt, in their largeneſs and ſolidity, ſo far ſurpaſs whatever we know of edifices, that we ſhould be ready to doubt of the reality of their having ever exiſted, did they not ſtill ſubſiſt to this day. Mr. De Chezele, of the academy of ſciences, who travelled into Egypt in the laſt century, to meaſure them, aſſigns to one of the ſides of the baſe of the higheſt pyramid, a length of ſix hundered and ſixty feet, which reduced to its perpendicular altitude, makes four hundred and ſixty-ſix feet. The free-ſtones, of which it is compoſed, are each of them thirty feet long; ſo that we cannot imagine, how the Egyptians found means to rear ſuch heavy maſſes to ſo prodigious a height. The Coloſſus of Rhodes was another of the marvellous productions of the ancients. To give an idea of its exceſſive bigneſs, it need only be obſerved, that the fingers of it were as large as ſtatues, and very few were able with out-ſtretched arms to encompaſs the thumb. Pliny and Diodorus Siculus relate, that

Semiramis

Semiramis made the mountain Bagiſtan, between Babylon and Media, be cut out into a ſtatue of herſelf, which was ſeventeen ſtadia high; that is, near two miles: and around it were a hundred other ſtatues, of proportionable ſize, though leſs large. And Plutarch ſpeaks of a very great undertaking, which one Steſicrates propoſed to Alexander; viz. to make a ſtatue of him out of mount Athos, which would have been a hundred and fifty miles in circumference, and about ten in height. His deſign was to make him hold in his left hand a city, large enough to contain ten thouſand inhabitants; and in the other an urn, out of which ſhould flow a river, poured by him into the ſea. See alſo the ſame Plutarch, vol. 1. p. 705. But Nitruvius gives to this ſtatuary the name of Dinocrates.

10. In ſhort, what ſhall we ſay of the other ſtructures of the ancients, which ſtill remain to be ſpoken of? Of their cement, which in hardneſs equalled even marble itſelf; of the firmneſs of their highways, ſome of which were paved with large blocks of black marble; and of their bridges, ſome of which ſtill ſubſiſt, irrefragable monuments of the greatneſs of their conceptions. The bridge at Gard, three leagues from Nimes, is one of them. It ſerves at once as a bridge and an aqueduct. It goes acroſs the river Gardon, and joins together the two mountains, between which it is encloſed. It comprehends three ſtories; the third is the aqueduct, which conveys the waters of the Eure into a great reſervoir, which ſupplies the amphitheatre and city of Nimes. The bridge of Alcantara, upon the Tagus, is ſtill a work fit to raiſe in us a great idea of the Roman magnificence: it is ſix hundred and ſeventy feet long, and contains ſix arches, each of which meaſures above a hundred feet from one pier to the other; and its height from the ſurface of the water is two hundred feet. The broken remains of Trajan's bridge over the Danube are ſtill to be ſeen; which had twenty piers of free-ſtone, ſome of which are ſtill ſtanding, a hundred and fifty feet high, ſixty in circumference, and diſtant one from another a hundred and ſeventy. I ſhould never end, were I to enumerate all the

the admirable monuments left us by the ancients: the ſlight ſketch here given of them will more than ſuffice, to anſwer my purpoſe. As to the ornaments and conveniences of their buildings, among many I ſhall mention but one, that of their uſing glaſs in their windows, and in the inſide of their apartments, juſt in the ſame manner as we do. Seneca and Pliny inform us, that they decorated their rooms with glaſſes; and do not we the ſame, in the uſe of mirrors and pier-glaſſes? But what will now ſhock the general prejudice is, that they ſhould know how to glaze their windows, ſo as to enjoy the benefit of light, without being injured by the air; yet this they did very early. Before they diſcovered this manner of applying glaſs, which is ſo delightful and ſo commodious, the rich made uſe of tranſparent ſtones in their windows, ſuch as the agate, the alabaſter, the phengites, the talcum, &c. whilſt the poor were under the neceſſity of being expoſed to all the ſeverities of wind and weather.

11. If we admire the ancients in thoſe monuments, which remain to us, of the greatneſs of their undertakings, we ſhall have no leſs reaſon for wonder, in contemplating the dexterity and ſkill of their artiſts in works of a quite different kind. Their works in miniature are well deſerving of notice. Archytas, who was contemporary with Plato, is famous in antiquity for the artful ſtructure of his wooden pigeon, which imitated the flight and motions of a living one. Cicero, according to Pliny's report, ſaw the whole Iliad of Homer written in ſo fine a character, that it could be contained in a nut-ſhell. And Elian ſpeaks of one Myrmeſides, a Mileſian, and of Callicrates, a Lacedemonian; the firſt of whom made an ivory chariot, ſo ſmall and ſo delicately framed, that a fly with its wing could cover it; and a little ivory ſhip of the ſame dimenſions: the ſecond formed ants and other little animals out of ivory, which were ſo extremely ſmall, that their component parts were ſcarcely to be diſtinguiſhed. He ſays alſo in the ſame place, that one of thoſe artiſts wrote a diſtich in golden letters, which he encloſed in the rind of a grain of corn.

12. It

12. It is natural here to inquire, whether in ſuch undertakings as our beſt artiſts cannot accompliſh, without the aſſiſtance of microſcopes, the ancients had not any ſuch aid; and the reſult of this reſearch will be, that they had ſeveral ways of helping the ſight, of ſtrengthening it, and of magnifying ſmall objects. Jamblichus ſays of Pythagoras, that he applied himſelf to find out inſtruments as efficacious to aid the hearing, as a rule, or ſquare, or even optic glaſſes, were to the ſight. Plutarch ſpeaks of mathematical inſtruments, which Archimedes made uſe of, to manifeſt to the eye the largeneſs of the ſun; which may be meant of teleſcopes. Aulus Gellius, having ſpoken of mirrors, that multiplied objects, makes mention of thoſe which inverted them; and theſe of courſe muſt be concave or convex glaſſes. Pliny ſays, that in his time artificers made uſe of emeralds to aſſiſt their ſight, in works that required a nice eye; and, to prevent us from thinking that it was on account of it's green colour only that they had recourſe to it, he adds, that they were made concave, the better to collect the viſual rays; and that Nero made uſe of them in viewing the combats of the gladiators. In ſhort, Seneca is very full and clear upon this head, when he ſays, that the ſmalleſt characters in writing, even ſuch as almoſt entirely eſcape the naked eye, may eaſily be brought to view, by means of a little glaſs-ball filled with water, which had all the effect of a microſcope, in rendering them large and clear: and indeed this was the very ſort of microſcope, that Mr. Gray made uſe of in his obſervations. To all this add the burning-glaſſes made mention of before, which were in reality magnifying glaſſes: nor could this property of them remain unobſerved.

13. It would be a needleſs taſk, to undertake to ſhew, that the ancients have the pre-eminence over the moderns in architecture, engraving, ſculpture, medicine, poetry, eloquence, and hiſtory. The moderns themſelves will not conteſt this with them: on the contrary, the height of their ambition is, to imitate them in thoſe branches of ſcience. And indeed what

poets

poets have we to produce, fit to be compared with Homer, Horace, and Virgil; what orators equal to Demoſthenes and Cicero; what hiſtorians to match Thucidides, Xenophon, Tacitus, and Titus Livius; what phyſicians, ſuch as Hippocrates and Galen; what ſculptors like Phidias, Polycletus, and Praxiteles; what architects to rear edifices ſimilar to thoſe, whoſe very ruins are ſtill the object of our admiration? Till we have thoſe, whom we can place in competition with the ancients in theſe reſpects, it will become our modeſty to yield to them the ſuperiority.

14. 'Tis worth notice, that the merit of the ancients is generally moſt controverted by thoſe, who are leaſt acquainted with them. There are very few of thoſe, who rail at antiquity, qualified to reliſh the original beauties of the Iliad, Æneid, and other immortal performances of the authors juſt enumerated. There are fewer ſtill, who are capable at one view to take in all that variety of ſcience, which hath been laid before the reader, and which comprehends in it almoſt the whole circle of our knowledge. Of the remaining admirable monuments, which ſhew to what perfection the ancients carried the arts of ſculpture and deſign, how few have taken any due notice; and of thoſe, how very few have been able to judge of their real value? True it is, that time and the hands of barbarians have deſtroyed the better part of them; yet ſtill enough is left to prove the excellence of what hath periſhed, and to juſtify encomiums beſtowed on them by hiſtorians. The group of figures in the Niobè of Praxiteles,* and the famous ſtatue of Lacoon,† ſtill to be ſeen at Rome, are and ever will be models of beauty and true ſublime in ſculpture; where much more is to be admired, than comes within the comprehenſion of the eye. The

* Some ascribe this piece to Scopas, the contemporary of Phidia, and who reached the times of Praxiteles. It is still in being, and to be seen at Rome.

† The joint labour of Agesander, Polydorus, and Athenodorus of Rhodes, who, according to Maffeus, lived all of them about the eighty-eighth Olympiad; it is in the Belvidere at Rome.

Venus de medicis,* the Hercules ſtifling Anaticus,† that other Hercules, who reſts upon his club,‡ the dying Gladiator,‖ and that other in the vineyard of Borgheſe,§ the Apollo of the Belvidere,¶ the maimed Hercules of the ſame place, and the Equerry in the action of breaking a horſe on mount Quirinal,** are all of them monuments, which loudly proclaim the juſt pretenſions of the ancients to a ſuperiority in thoſe arts. Theſe pretenſions are ſtill further ſupported by their remaining medals, the precious ſtones of their engraving, and their cameos. There is ſtill to be ſeen a ſilver medal of Alexander the Great, on the reverſe of which there is Jupiter ſitting on his throne, finiſhed with the fineſt ſtrokes of art; not a feature, even the ſmalleſt, but ſeems to declare his divinity. The ſtones engraved by Pyrgoteles, who had an excluſive privilege of engraving Alexander's head, as Lyſippus had of making his ſtatue, and Apelles of painting him; thoſe of Dioſcorides, who engraved the heads on the ſeals of Auguſtus; the celebrated Meduſa, Diomedes, Cupid, and other performances of Solon; in ſhort, all the other eminent pieces of ſculpture and engraving, ſo carefully ſought after by the curious, and with ſo much reaſon admired by connoiſſeurs, render it needleſs for

* The workmanship of Cleomenes, the Athenian, ſtill to be ſeen in the Farnesian palace at Florence.

† Aſcribed to Polycletus, who made the Coloſſial ſtatues of Juno in gold and ivory at Argos, which no longer exiſt.

‡ The work of Glycon, ſtill remaining in the Farnesian palace at Florence.

‖ Done by Ctesilas, or Ctesias, in the gallery of the Capitol.

§ By Agathias of Ephesus.

¶ By the ſame. The two laſt were at Antium, now Nettuno.

** Aſcribed by ſome to Phidias, by others to Praxiteles. Thoſe, who aſſign it to the latter, imagine it to be that of Alexander breaking Bucephalus. But if it was done by the former, it muſt be another ſubject, that ſculptor having flouriſhed about a century before. It is thought, that nothing of this is now remaining. His Olympian Jupiter was an object of admiration for many ages, and continued ſtill at Conſtantinople, in the beginning of the thirteenth century; together with the beautiful Cnidan Venus, the handy work of Praxiteles, and the ſtatue of Opportunity by Lyſippus. It is probable, theſe fine remains were deſtroyed at the taking of the city by Baldwin.

me to enlarge on the praiſes of artiſts ſufficiently renowned, by being the authors of works ſo laſting and ſo precious.

15. As to painting ſo few, and ſo ſcanty are the reliques, and ſo much more injured by time, than the ſtatues and other remains of ſculpture in bronze and marble, that to form a proper judgment of the merit of the ancients in it, appears at firſt very difficult. Yet if due attention be paid to what of that kind has been diſcovered at Rome, and more lately in the ruins of Herculaneum, we ſhall be obliged to admit the juſtice of that applauſe, which the painters of antiquity received from their contemporaries; an applauſe confirmed by all we have had occaſion to obſerve of their excellency in ſculpture. The ancient paintings in freſes, ſtill to be ſeen at Rome, are, a reclining Venus at full length *, and ſeven other pieces †, taken out of a vault at the foot of Mount Palatine; among which are a ſatyr drinking out of a horn, and a landſcape with figures, both of the utmoſt beauty. There are alſo a ſacrificial piece, conſiſting of three figures ‡, and an Œdipus, and a ſphynx; which all of them formerly belonged to the tomb of Ovid §. Theſe are ſpecimens from which, without temerity, we may form a very advantageous judgment of the ability of the maſters who executed them; but thoſe diſcovered at Herculaneum, diſcloſe, beyond all others, a happineſs of deſign and boldneſs of expreſſion, that could proceed only from the hands of the moſt accompliſhed artiſt. The picture of Theſeus vanquiſhing the Minotaur, that of the birth of Telephus, that of Chiron and Achilles ‖, and that of Pan and Olympe, preſent innumerable beauties to all who have diſcernment, and ſtrike moſt the eye of the more intelligent beholder. If indeed we examine the countenance of Achilles in the original picture itſelf, and not in the imperfect impreſſion publiſhed of it, we ſhall perceive in it ſomething inimitably

* In the palace of Barbarini.
† In the gallery of the college of St. Ignatius.
‡ In the poſſeſſion of Cardinal Alexander Albani.
§ In the Villa Altieri.
‖ These two are, perhaps, the performances of Parrhaſius.

juſt and fine in its air, energy and expreſſion; every thing contributes to diſplay the young hero's ardour for glory; and he looks with ſuch eagerneſs and impatience on his maſter as if he wanted but an opportunity to acquire it at all hazards. There were found alſo, among the ruins of that city, four capital pictures, wherein beauty of deſign ſeems to vie with the moſt ſkilful management of the pencil. They appear to be of an earlier date, than thoſe we have ſpoken of, which belong to the firſt century; a period when painting, as Pliny informs us, was in its decline. What then are we to think of the paintings of Zeuxis and Apelles, when even this art itſelf, in its very decline, was capable of exhibiting ſuch productions as theſe, which, however juſtly exciting our praiſe, ſeem to have been but of an inferior kind, when compared to the noble performance of thoſe great maſters? This accounts for the ſilence obſerved by Pliny, and the other hiſtorians, in relation to them.

16. Another kind of work, of affinity to painting, and which deſerves to find a place here, is the moſaic, which the Romans made uſe of in paving their apartments. One of the moſt beautiful monuments of that kind, and elegantly deſcribed by Pliny, was found ſome years ago in the ruins of Adrian's famous country-ſeat at Tivilo. It repreſents a baſon of water, with four pigeons around the brim of it, one of which is drinking, and in that attitude its ſhadow appears in the water. Pliny in the ſame place ſays, that on the ſame pavement the breaking up of an entertainment was ſo naturally repreſented, that you would have thought you really ſaw the ſcattered fragments.

17. Muſic is as ancient as the world. It ſeems to have been born with man, to accompany him in his painful career, to ſweeten his labours, and charm away his cares. This was its firſt employment. It was afterwards conſecrated to divine ſervice, and having thus riſen in its dignity, became of principal account among the people, in accompanying the traditional narratives, relative to the characters and exploits of their anceſtors.

anceſtors. Hence it came to be the firſt ſcience wherein their children were inſtructed. Muſic, and poetry its ally, accompanied all their ſtudies. They even deified thoſe, who firſt diſtinguiſhed themſelves in it; Apollo was of this number. Orpheus, Amphion, and Linus, for their eminent talents in this art, were accounted more than men. Philoſophers applied themſelves to it; Pythagoras, Socrates, and Plato, recommended it as worthy of being cultivated, not only by their diſciples, but by the beſt regulated ſtates. The Grecians, and particularly the Arcadians, enacted the ſtudy of it by law; regarding it as indiſpenſably neceſſary to the common welfare. A ſcience ſo generally cultivated, ſhould have arrived at perfection very early; yet did it continue in a ſtate of imbecility and without principles till the times of Pythagoras. We have ſeen before in what manner this great man firſt determined its fundamental rules.

Till his time muſic was ſo vague and uncertain, that it required an extraordinary effort of genius to reduce it to method and order. He preciſely determined the proportions which ſounds bear one to another, and regulated harmony upon mathematical principles. But he let the preciſion of his mind carry him too far, in ſubjecting muſic to the judgment of reaſon alone, and admitting no pauſes or reſts, but ſuch as had an arithmetical or geometric proportion in them. Ariſtoxenes, the diſciple of Ariſtotle, thought, on the contrary, that this ſubject, came entirely within the verge of hearing, and that the ear was the only judge of ſounds. He therefore regulated the order, the uniſon and break in tones, ſolely by the judgment of the ear; and his ſyſtem prevailed for ſome time in Greece. Olympus, a Phrygian, came ſoon after to Athens, who invented a ſtringed inſtrument which gave the ſemi-tones, whereby he introduced ſo many new graces into muſic, as gave it entirely another air. He joined Ariſtoxenes, appealing for the merit of his ſyſtem to the deciſion of the ear. At length the famous Ptolemy appeared, and with ſuperior ſpirit equally diſclaimed the partiality of both ſides. He took a middle courſe, aſſert-

ing that ſenſe and reaſon had a joint right to judge of ſounds. He accuſed the Pythagoreans of fallacy in their ſpeculations, with reſpect to proportions; as well as of folly in ſo diſregarding the deciſions of the ear, as to refuſe it that kind of harmony which was agreeable to it, merely becauſe the proportions of it did not correſpond with their arbitrary rules. And he charged the partizans of Ariſtoxenes with an abſurd neglect of reaſoning, in that though they were convinced of the difference of grave and acute tones, and of the proportions ſubſiſting between them; and that thoſe proportions invariably depended upon the ſeveral lengths of the muſical chords; yet they never took the trouble of conſidering this, ſo as to enter into the reaſon of it. He therefore determined in deciding upon the principles of harmony, to make uſe not only of reaſon but alſo of the ear, as being of aid to one another; and in conſequence of this laid down a ſure method for finding out the proportions of ſounds. Had the ancients done no more with reſpect to muſic, than made the diſcoveries already taken notice of, that ſcience muſt be infinitely more indebted to them, than it poſſibly could be to thoſe who ſucceeded them, for what additions they have afterwards made. The ancients have the whole merit of having laid down the firſt exact principles of muſic; and the writings of the Pythagoreans, of Ariſtoxenes, Euclid, Ariſtides, Nicomachus, Plutarch, and many others, even ſuch of them as ſtill remain, contain in them every theory of muſic yet known. They knew, as well as we, the art of noting their tunes, which among them was called the paraſemantic, or ſemeiotic, performed by means of entire letters either contracted or reverſed, placed upon a line parallel to the words, and ſerving for the direction, the one of the voice, the other of the inſtrument; and the ſcale itſelf, of which Guy Aretin is the ſuppoſed inventor, is no other than the ancient one of the Greeks a little enlarged, and what Guy may have taken from a Greek manuſcript, written above eight hundred years ago, which Kirchner ſays he ſaw at Meſſina, in the library of the Jeſuits, wherein he found the hymns noted, juſt as in the manner of Aretin.

18. As

18. As to the effects, which muſic produced, and the manner of performing it, ſo far were the ancients from falling ſhort of the moderns in theſe reſpects, that as to the former, after reducing the accounts we have of it to the moſt rigid conformity to truth, they ſtill appear therein to have gone far beyond us: and as the latter, though it be alledged, that their inſtruments were not ſo complete as ours, and that they knew not, nor put in practice thoſe diviſions in harmony, which enter into our concerts; yet this ſeems to be a groundleſs objection. The lyre, for inſtance, was certainly a very harmonious inſtrument, and in Plato's time was ſo conſtructed, and ſo full of variety, that he regarded it as dangerous, and too apt to relax the mind. In Anacreon's time, it had already obtained forty ſtrings. Ptolemy and Porphyry deſcribe inſtruments reſembling the lute and theorbo, having a handle with keys belonging to it, and the ſtrings extended from the handle over a concave body of wood. There is to be ſeen at Rome an ancient ſtatue of Orpheus, with a muſical bow in his right hand, and a kind of violin in his left. In the commentaries of Philoſtratus by Vigenere, is a medal of Nero with a violin upon it. In the paſſages referred to below, it plainly appears, that the flute was carried to ſo high a degree of perfection by the ancients, that there were various kinds of them, and ſo different in ſound, as to be wonderfully adapted to expreſs all manner of ſubjects. And in Tertullian we meet with a very full deſcription of an hydraulic organ, invented by Archimedes, which was ſo far from being inferior in any reſpect to ours, that it plainly exceeded them in its mechaniſm, as being made to play by water. "Behold," ſays Tertullian, "that aſtoniſhing and admirable hydraulic organ of Archimedes, compoſed of ſuch a number of pieces, conſiſting each of ſo many different parts, connected together by ſuch a quantity of joints, and containing ſuch a variety of pipes for the imitation of voices, conveyed in ſuch a multitude of ſounds, modulated into ſuch a diverſity of tones, breathed from ſo immenſe a combination of flutes: and yet all taken together conſtitute but one ſingle inſtrument."

19. Should

19. Should we for the preſent confine our views only to harmony, or the conſenting notes in muſic, we ſhall find that the ancients were by no means ignorant of it. Many reſpectable authors have curſorily treated of it. Macrobius ſpeaks of five notes, among which the baſe bears ſuch a ſymphony with thoſe above it, that however different they be among themſelves, they come to the ear as if they altogether compoſed but one ſound. Ptolemy, ſpeaking of the monochord, calls it a mighty ſimple inſtrument, as having neither uniſon, accompanyment, variety, nor complication of ſounds. Seneca, in one of his letters, ſays to his friend, "Don't you obſerve how many different voices a band of muſic is compoſed of? There you have the baſe, the higher notes, and the intermediate, the ſoft accents of women, and the tones of men, intermingled with the ſound of flutes, which, however ſeparately diſtinct, form altogether but one harmony of ſound, in which each bears a ſhare." Plato ſufficiently makes it appear, that he knew what harmony was, when he ſays, that muſic is a very proper ſtudy for youth, and ſhould employ three years of their time; but that it was improper to put them upon playing alternately in concert, it being enough for them, if they could accompany their voice with the lyre. And the reaſon he gives for it is, that the accompanyment of various inſtruments, the baſe with thoſe of a higher key, and the variety, and even oppoſition of ſymphonies, where muſic is played in diviſions, can only embarraſs the minds of youth. True it is, the ancients did not much practiſe compound muſic; but that proceeded only from their not liking it. For Ariſtotle, after aſking, why one inſtrument accompanied only by a ſingle voice gave more delight, than that very voice would do with a greater number, replies, that the multitude of inſtruments only obſtructed the ſound of the ſong, and hindered it from being heard. Yet the ſame author in another place, expreſsly ſays, that muſic, by the combination of the baſe and higher tones, and of notes long and ſhort, and of a variety of voices, ariſes in perfect harmony. And in the following chapter, ſpeaking of the revolutions of the ſeveral planets,

as perfectly harmonizing with one another, they being all of them conducted by the ſame principle, he draws a compariſon from muſic to illuſtrate his ſentiments; Juſt as in a chorus, ſays he, of men and women, where all the variety of voices, though all the different tones, from the baſe to the higher notes, being under the guidance and direction of a muſician, perfectly correſpond with one other, and form a full harmony. Aurelius Caſſiodorus defines ſymphony to be the art of ſo adjuſting the baſe to the higher notes, and them to it, through all the voices and inſtruments, whether they be wind or ſtringed inſtruments, that thence an agreeable harmony may reſult. And Horace ſpeaks expreſsly of the baſe and higher tones, and the harmony reſulting from their concurrence. All theſe teſtimonies therefore uniting in favour of the harmony of the ancients, ought not to leave us the leaſt doubt reſpecting this branch of their knowledge. We have ſeen the reaſon why they did not much uſe harmony in concert. One fine voice alone, accompanied with one inſtrument, regulated entirely by it, pleaſed them better than mere muſic without voices, and made a more lively impreſſion on their feeling minds. And this is what even we ourſelves every day experience.

20. I come now to conſider the effects, which the ancient muſic produced, and begin with obſerving, that it is not at all probable they would unanimouſly conſent to impoſe upon poſterity, in matters delivered with ſuch an air of truth. There is ſcarcely any thing in hiſtory better ſupported. To begin with ſacred ſtory. We find there, that the miniſters of Saul bid him ſend for a player upon an inſtrument, to relieve him of his malady. The conſequence of this was, that David came, and adminiſtered the expected relief. And to be convinced, that there was nothing ſupernatural in this, but that muſic was at that time a known ſpecific in ſuch maladies as Saul complained of, it need only be remarked, that thoſe, who gave this advice, were but houſehold ſervants. Profane hiſtory ſupports us in this reflection, by a great number of inſtances of the ſame kind. Aulus Gellius and Athenœus make mention of

many

many cures performed among the Thebans by muſic, and cite Theophraſtus as to what happened in his time. Galen, a very grave author, and whoſe authority is of the greateſt weight in ſubjects of this kind, ſpeaks very ſeriouſly of this cuſtom. And Ariſtotle, Appollonius, Dipſcolus, Capella, and many others, ſpeak of ſinging as a noſtrum in many maladies. There is a paſſage in Tzetzes, which give riſe to a conjecture, that may very naturally accompany theſe facts. He ſays, that Orpheus recalled Eurydice from the gates of death, by the charms of his lyre. Now to take this literally, one might preſume from it, that Eurydice had been bit by a tarantula inſtead of a ſerpent, as hiſtorians give out, and that Orpheus having recovered her by means of muſic, as is practiſed in Italy even at this day, in proceſs of time there was founded on this the well-known allegory of his deſcent into hell. But if, in oppoſition to this, it be alledged, that there are no tarantulas in Thrace, (which is what I cannot take upon me to affirm) the objection is eaſily evaded by admitting with hiſtorians, that ſhe was really bit by a ſerpent, obſerving withal, that ſhe might ſtill be cured of that bite by means of muſic. Theophraſtus, among other writers, is quoted by Aulus Gellius, as an ocular evidence of the medical effects of muſic, in the caſe of perſons bit by ſerpents or vipers. The work indeed referred to is now loſt. Another purpoſe, to which the ancients applied their muſic, was to alleviate the rigour of their puniſhments; and in this they diſplayed their humanity. The Americans entertain the ſame idea of the power of muſic, having recourſe to it to allay the ſeverity of their toils. Plutarch reports of Antigenidas, that he ſo rouſed the ſpirit of Alexander, by playing on the flute, that in a tranſport of heroiſm the prince immediately ſtarted up from table, and flew to his arms. Every body hath heard of the wonderful influence, which the muſic of the famous Timotheus had over the mind of that prince, when touching his lyre, he ſo inflamed him with rage, that drawing his ſabre he ſuddenly ſlew one of his gueſts; which Timotheus no ſooner perceived, than, altering the air from the Phrygian to a ſofter meaſure, he ſtripped him of his fury,

becalmed

becalmed his paſſion, and infuſed into him the tendereſt feelings of grief and compunction for what he had done. Jamblicus relates like extraordinary effects of the lyres of Pythagoras and Empedocles. The painter Theon dextrouſly availed himſelf of this force of muſic, when going to make a public exhibition of a piece he had finiſhed, wherein a ſoldier was repreſented as juſt ready to aſſail the enemy, he firſt of all warmed the ſpirit of the company by a warlike air, and when he found them ſufficiently animated, uncovered the picture, which ſtruck the whole aſſembly with admiration. Plutarch informs us of a ſedition quelled at Lacedemon by the lyre of Terpander; and Boetius of rioters diſperſed by the muſician Damon.

21. To conclude this inquiry reſpecting the merit of the ancients in muſic, I ſhall make but two obſervations. The firſt is, that their airs in delicacy very much ſurpaſſed ours, and that it is in this reſpect principally, that we may be ſaid to have loſt their muſic. Of their three kinds of muſic, the diatonic, chromatic, and the enharmonic, there exiſts now only the firſt * and ſecond. The difficulty there was to find voices and hands proper to execute the enharmonic kind, brought it firſt into neglect, and then into oblivion; inſomuch that all now remaining of the ancient muſic is that coarſer ſort, which knows no other refinement, than that of the whole and the deminote, inſtead of theſe finer kinds, which carried on the diviſion of a note into threes and fours. Doubtleſs the prevalency of that ſyſtem, which referred the determination of ſounds to the judgment of the ear, occaſioned the rejection of the enharmonic ſpecies, which was too fine for the deciſion of the ear, and ſprung entirely from the Pythagoric ſyſtem. But this by no means ought to hinder us from acknowledging the excellency of that muſic above the modern, in the extreme delicacy of its tones. The ſecond obſervation is, that the variety of manner, in

* Dutens is mistaken in saying, first, that only the first, viz. the diatonic kind, now remains; and, secondly, that this divides the tones into semitones; which certainly is done by the chromatic, and not the diatonic scale.

which the ancient muſic was performed, placed it in a rank of dignity ſuperior to ours. Our modes are but of two kinds, the flat and the ſharp: whereas the ancients, modified theirs into five, the principal of which were the Ionic, the Lydian, the Phrygian, the Doric, Æolic; each adapted to expreſs and excite different paſſions; and by that means, eſpecially, to produce ſuch effects as we have juſt now taken notice of, not only from the authentic manner, in which they have been recorded, but from the very ſtate and condition, in which muſic at that time was.

The Conclusion.

1. We have ſeen in how many truths of the greateſt importance, the ancients preceded the moderns, or at leaſt pointed out, or prepared the way for their diſcoveries. It appears alſo, that the latter have not always had the diſintereſtedneſs to own, that the former guided them in attaining their ends. And here it may not be amiſs to remark, that thoſe very philoſophers, when their opinions were attacked, or when they dreaded they might be ſo, recurred to the authority of thoſe great men, to put envy and calumny to ſilence. Deſcartes, Mallebranche, and ſome Newtonians, are inſtances of this.

2. The firſt of theſe, at the concluſion of his principles of philoſophy, adverti ſes the reader, that he had advanced nothing but what had been authorized by Ariſtotle, Democritus, and many other philoſophers of antiquity. Mallebranche, obſerving his ſyſtem accuſed not only of being falſe, but of being impious, immediately had recourſe to the authority of St. Auguſtin. And ſome Newtonians, upon ſeeing that attraction was by many regarded as a mere whim, ſet about proving, that the ancients owned and taught it; truſting by this to open a reception for it. Some, to conciliate the favour of the public, have had recourſe to the authority of the ancients; others, upon being attacked, have fled to them for ſuccour and protection. Others again, diſtruſting their own ability to ſupport what

what they advanced, have rather choſen to abdicate the glory of invention, than give up their favourite ideas a prey to their adverſaries; and have therefore, to put them out of reach, placed their origin at a vaſt diſtance. Nor are there wanting thoſe, who, ſeeing themſelves ſecure of ſucceſs, in hazarding certain opinions, have ventured to paſs them under their own names, though they belonged to others; and obſerving, that they were not reclaimed to their real authors by the public, have ſilently gloried in their borrowed luſtre; many conſcious that they had no right, and ſome, though few in number, thinking that they had.

3. What little we have taken notice of, reſpecting the conduct of Deſcartes, Locke, and Mallebranche, is ſufficient to authorize what we here advance. Deſcartes hath not ſpecified the authors, from whom in particular he derived his thoughts. He only ſays in general, that the greateſt philoſophers of antiquity have thought as he has done. Locke hath paſſed for an original, though his principles be the ſame with thoſe of Ariſtotle, and his diſtinctions juſt ſuch as were employed by the ſtoics. Mallebranche did not at firſt avow, that his opinion was the ſame with that of the Chaldeans, Parmenides, Plato, and St. Auguſtin; but when he ſaw himſelf warmly attacked by his adverſaries, againſt the philoſophical part of them, he held up the buckler of Plato, whilſt he fled to St. Auguſtin for ſhelter againſt the divines. The glory of having been the firſt, who clearly diſtinguiſhed the properties of the mind from thoſe of the body, and demonſtrated, that ſenſible qualities had their exiſtence in the mind of the percipient, and not in the object perceived, hath been wrongfully aſcribed to Deſcartes; ſince we have ſeen, that he was preceded in all theſe reſpects by Leucippus, Democritus, Plato, Strato, Ariſtippus, Plutarch, and Sextus Empiricus.

4. Leibnits hath not only revived the doctrine of Pythagoras, but employed the very ſame arguments, which the Pythagoreans made uſe of to demonſtrate the neceſſity of admitting the exiſtence of ſimple and uncompounded

uncompounded things, anterior to thoſe that were compounded, and as being the foundation of the exiſtence of body itſelf. Mr. de Buffon hath ſometimes quoted Ariſtotle and Hippocrates, but never when there was any inquiry about the ground-work of his ſyſtem, which has always been thought to be new, though it appears to be almoſt entirely the ſame with that of Anaxagoras, Empedocles, and Plotinus. According to the ſyſtem of Pythagoras, Plato, and Epicurus, the production of every thing in nature was aſcribed to the concurrent force of ſimple and active principles, long before Mr. Needham thought of it. The philoſophy of Gaſſendi and the Newtonians, is no other than that of Moſchus, Leucippus, Democritus, and Epicurus. The acceleration of motion was known to Ariſtotle, and the beſt manner of accounting for it is that which he makes uſe of. Lucretius obſerved, long before Galileo, that bodies the moſt unequal in weight, ſuch as gold and down, muſt deſcend with equal velocity in a vacuum. Univerſal gravity attractive, centripetal, and centrifugal force, were clearly indicated by Anaxagoras, Plato, Ariſtotle, Plutarch, and Lucretius. We have alſo ſeen, that, without the aid of teleſcopes, Democritus and Phavorinus entertained very juſt ideas of the milky way, and predicated the diſcovery of the ſatellites; that a plurality of worlds, and the doctrine of vortices, were clearly and with preciſion taught by the ancients; and that Plato had a notion of the theory of colours. We have ſeen, that two thouſand years before Copernicus, Pythagoras had propoſed the ſame ſyſtem; and that Plato, Ariſtarchus, and many others, had admitted it; as they did alſo, without difficulty, the doctrine of antipodes, which, though very reaſonable in itſelf, had ſo much difficulty in gaining a reception among us. The revolution of the planets about their own axis was known alſo in the ſchools of Pythagoras and Plato. There was nothing left to the moderns to ſay new, reſpecting the return of comets, their nature, and their orbits. The Chaldeans, Egyptians, Pythagoras, Democritus, Hippocrates of Chios, Artemidorus, and Seneca, had already fully ſettled the theory of them; though the moderns, it is true, demonſtrated

monſtrated more clearly ſome parts of it. The mountains, vallies, and inhabitants of the moon had been ſuggeſted and ſuppoſed by Orpheus, Pythagoras, Anaxagoras, and Democritus.

5. Ariſtotle knew the weight of the air; Seneca its ſpring and elaſticity. Leucippus, Chryſippus, Ariſtophanes, and the ſtoics, had fully accounted for thunder and earthquakes. Pytheas, and Seleucus of Erythrea, preceded Deſcartes in explaining the cauſe of the ebbing and flowing of the ſea; and Pliny, before Sir Iſaac Newton, had made mention, in that caſe, of the combined forces of ſun and moon.

6. We have alſo ſeen, that Hippocrates and Plato knew the circulation of the blood, and that Rufus deſcribed, 1600 years ago, the varicous paraſtatæ, called by us the Fallopian tubes. And by the ſentiment of an able ſurgeon of the preſent age, we have ſhewn, that there were as great advances made in that art a thouſand years ago, as there are at preſent. The art of working metals, of rendering gold potable, glaſs ductile and malleable; that of diſtillation, of painting upon glaſs, of making gun-powder, and a thouſand other chymical preparations, with which we have proved the ancients to have been acquainted, leave not the leaſt doubt of their ſkill in chymiſtry. We have ſeen, that the ſentiment of Harvey, Steno, and Rhedi, reſpecting generation by eggs, was only a renewal of what had been taught by Hippocrates, Empedocles, Ariſtotle, and Macrobius; and the ſyſtem of Hartſoëker and Leuwenhoek, with reſpect to ſpermatic animalcula, is found in Ariſtotle, Hippocrates, Plato, Lactantius, and Plutarch. And the ſexual ſyſtem of plants, the merit of diſcovering which we chiefly aſſign to Morland, Grew, Vaillant, and Linnæus, was accurately expounded by Empedocles, Theophraſtus, Pliny, and Diodorus Siculus.

7. Though we did not employ much time in our ſurvey of mathematics and geometry, yet we made it appear, that the nobleſt diſcoveries in thoſe ſciences were

were made by the ancients. All the Engliſh geometricians agree with Leibnits and Wolf in acknowledging, that, notwithſtanding all the attempts made by the ableſt geometricians in theſe laſt ages, Euclid's method ſtill remains the moſt accurate and perfect. We obſerved, that the moſt difficult problems in thoſe ſciences were ſolved by Thales, Pythagoras, Plato, Archimedes, and Apollonius. We have ſeen, that their mechanical contrivances were carried to ſuch a pitch, as to ſurpaſs even the conception of the moſt learned among us. Archimedes's burning glaſſes furniſhed us with an inſtance of this. Their application of the equal vibration of the pendulum, their knowledge of the refraction of light, and its cauſe, their attempts to ſquare the circle, their diſcovery of the fundamental propoſitions of geometry, and above all that of algebra, and the proceſſion of the equinoxes, afford convincing proofs of the depth and acuteneſs of the genius of the ancients. We have alſo made it appear, that microſcopes were not unknown to them; and that in the arts of painting, ſculpture, and the ſcience of muſic, they not only equalled, but even ſurpaſſed us. In laying before the eyes of the reader a ſketch of the admirable works of the ancients in architecture, and in the art of war, we have likewiſe given proofs, that they were no leſs able in the arts, than in the ſciences; inſomuch that there is no part of knowledge, in which they have not either preceded us, directed, or ſurpaſſed us.

8. Now, if it hath been demonſtrated, that the writings of thoſe great maſters contain the greateſt part of what is to be known, and that the moſt celebrated diſcoveries of the moderns have thence derived their origin; is it not very reaſonable, that we ſhould rather go to the fountain-head of ſcience, than to confine ourſelves entirely to the little ſtreams, that iſſue from it!

But in recommending the ſtudy of the ancients, I am far from thinking, that the moderns are to be neglected. I apprehend, on the contrary, that it is of great uſe attentively to conſider their labours, in order

to

to remark what they have added to the knowledge of the ancients by their experiments; for without doubt there may be daily added ſomething to our knowledge. This makes it neceſſary attentively to compare the ancients and moderns together; for in theſe laſt many things may be found, which have either been omitted, or but obſcurely treated of in the former. Nay, farther, the labours of the moderns may ſerve to replace, as it were ſome of thoſe treatiſes of the ancients, which have been loſt, and of which there now remain only the titles, to give us an idea of the greatneſs of our loſs. Another advantage, which may ariſe from this compariſon, is, to aſcertain us in our reflections; for where the ancients and moderns agree, it is natural, that their joint conſent ſhould determine our judgment in ſuch or ſuch a point. And even when they differ, the diverſity of their reaſonings may tend to throw light on the mind.

9. Free from partiality towards either, we ought to think, that whatever efforts have been made to bring our knowledge to perfection, there will remain ſomething ſtill to be done in that reſpect, by us and our poſterity. There is no man ſufficient of himſelf to eſtabliſh or perfect any one art or ſcience. Having received from our anceſtors the product of all their meditations and reſearches, we ought daily to add what we can to it, and by that means contribute all in our power to the increaſe and perfection of knowledge. Let us put on the diſpoſition of Seneca, who expreſſes himſelf on this ſubject with his uſual eloquence. "I hold in great veneration," ſays he, "the inventions of the wiſe, and the inventors themſelves. This is an inheritance, which every one may and ought to lay claim to. To me they have been tranſmitted; for me they have been found out." "But let us in this," continues he, "act like good managers; let us improve what we have received, and convey this heritage to our deſcendants, in better condition than it came to us. Much remains for us to do; much will remain for thoſe, who come after us. A thouſand years hence, there will ſtill be occaſion, and ſtill opportunity,

to

to add ſomething to the common ſtock. But had every thing been found out by the ancients, there would ſtill this remain to be done a-new, to put their inventions into uſe, and make their knowledge ours."

WHEN I firſt read over the preceding Treatiſe, I had little thought or deſign of making ſo large an extract from it. But I afterwards conſidered, 1. That this might be a means of making that valuable work more extenſively known, (as Men of learning would naturally deſire to ſee and examine the proofs at large) and 2. That it might ſerve for a kind of recapitulation of the preceding volumes. Such a recapitulation as, on the one hand, could not be unentertaining to the ſenſible Reader; and on the other, might repreſs the vanity which is apt to ariſe in our minds, when we imagine we have made new Diſcoveries. Alas! how little new has been diſcovered, even by Gaſſendi, Mallebranche, Mr. Locke, or Sir Iſaac Newton? How plain is it, that in Philoſophy, as well as the courſe of human affairs, there is nothing new under the ſun!

The more we conſider this, the more we ſhall be convinced of the inconceivable littleneſs of Human Knowledge. But although with our utmoſt efforts, we can know ſo ſmall a part of the things that ſurround us, yet we can know, and that with the greateſt certainty, our whole duty to Him that made them. And what can we reaſonably deſire more? For this is the whole of man, (which is the literal rendering of Solomon's words) his whole Buſineſs, his whole Happineſs. In this our infant ſtate we cannot know much: but we may love much. Let us ſecure this point, and we ſhall ſoon be ſwallowed up in the ocean both of Knowledge and Love!

London, Nov. 16, 1777.

APPENDIX.

APPENDIX.

BEFORE I conclude, it ſeems highly neceſſary to enlarge a little on ſome particulars, which were before but ſlightly mentioned.

One of theſe is the Human Underſtanding, which was juſt mentioned in the 4th Chapter of the Firſt Part. On this important head I now intend to ſpeak particularly; chiefly on the plan of the pious and learned Dr. Peter Brown, late Biſhop of Cork in Ireland.

It is needful, firſt, to trace out the bounds and extent of human underſtanding. Theſe bounds being fixed, we are next to conſider, how the mind dilates itſelf beyond them: how it ſupplies the want of direct ideas, by raiſing up ſecondary images in itſelf: inſomuch that things, otherwiſe imperceptible, grow familiar and eaſy; and we meditate and diſcourſe even on thoſe beings, whereof we have not the leaſt direct perception.

CHAP. I.

SECT. I.

Of the Ideas of Sensation.

OUR ſenſes are the only ſource of thoſe ideas, upon which all our knowledge is founded. Without ideas of ſome ſort or other we could have no knowledge,

knowledge, and without our ſenſes we could have no ideas. But theſe being once tranſmitted to the memory, the ſoul, which till then was ſtill an inactive being, ſupplied with materials to work upon, begins to exert her operations.

Before we ſpeak of the properties of ideas of ſenſation, it is proper to obſerve three things: 1. That it is not neceſſary to decide, whether ſenſitive perception be performed, by an impreſſion of the object upon the ſenſe, or by an operation of the ſenſe upon the object. It is certain, that either way of ſenſitive perception neceſſarily requires the preſence of the object, and an immediate action, either of the organ upon this, or of this upon the organ: conſequent upon which is a ſort of repreſentation of the object to the mind. This is the caſe of all external objects, which have left any repreſentation of themſelves with us by our ſenſes: which repreſentation being tranſmitted by the ſenſes to the memory, is properly termed an Idea.

If any one aſks, what an idea is, let him look upon a tree, and then immediately ſhutting his eyes, try if he retains any reſemblance of what he ſaw; and that is an idea. Thus it is, that all the variety of the viſible creation is let in upon our minds through the ſenſes, as all parts of a delightful and ſpacious landſcape are contracted, and conveyed into a dark chamber, through an artificial eye in the wall, and ſo become conſpicuous and diſtinguiſhed in miniature.

Nor, 2. Is it material, whether the ideas of ſenſible objects are true images of their real natures: or whether the objects be only the occaſions of producing theſe ideas, by virtue of an arbitrary law of God, that ſuch a thought in the ſoul ſhould follow ſuch a motion in the body. For whatever impreſſion ſenſible objects occaſion in us, this we call their idea; it being the only perception of them we are capable of, and the only way we now have of knowing them. And ſuch a way it is, as anſwers all the ends of knowledge in this life, and lays a ground-work ſufficient for all that knowledge, which is neceſſary in order to another.

The third thing proper to be mentioned is, that, to prevent confuſion, the word idea is, in all that follows, confined

confined to the images we have of ſenſible objects, and the various alterations of them by the underſtanding. And taking the word in this ſenſe, the mind has no idea of her own operations. For theſe are originally within us themſelves, and ſo are known by inward conſciouſneſs; not as outward things are, by any ſimilitude of them, conveyed through the ſenſes to the memory.

SECT. II.

Of the Idea of Spirits.

WHEN we obſerve ſuch effects among material things, as we know cannot proceed from any inherent power in them, we neceſſarily infer, there are ſome other beings not material which have the power of producing thoſe effects: though as theſe beings are imperceptible to our ſenſes, we have no idea of them.

It has been ſaid indeed, that we have as clear an idea of ſpirit, as we have of body; and to prove this, it is ſaid farther, that we conceive thinking, as clearly as we do extenſion. But what if we did? A pure ſpirit, if we ſpeak ſtrictly, does not think at all. Thinking is the property of an imbodied ſpirit, as requiring the concurrence of material organs, and being accordingly ever performed more or leſs to advantage, as theſe are better or worſe diſpoſed. They are ſoon relaxed by the labour of thought and attention, and muſt be conſtantly wound up anew by reſt and ſleep. A diſtemper puts the whole machine out of frame, and turns our ſober thinking into madneſs. And if the veſſels of the brain are entirely obſtructed, as in an apoplexy, we think not at all. How then can we imagine, that a pure ſpirit thinks? It knows indeed; but we cannot tell how: to be ſure, not by playing upon a ſet of material ſprings, exquiſitely wrought up into curious contexture for that purpoſe.

It is becauſe we have no idea of a ſpirit, that we are naturally led to expreſs it by a negative; to call it an immaterial ſubſtance, or ſomething that is not matter;

ter; ſomething that is not any thing that we know; which forces us to conceive and expreſs it in this imperfect manner.

Yet it has been affirmed farther, that we have as clear an idea of God himſelf, as we have of man; and that we are as ignorant of the eſſence of a man, as we are of the eſſence of God! Do we not then know, that it is eſſential to man to be finite? And have we not a diſtinct idea of Finiteneſs? But who has any idea of Infinity, the eſſential attribute of God? 'Tis plain, we have not: and therefore we expreſs it by a negative, "Without bound."

Properly ſpeaking, we have no idea of God. We come to our knowledge of his very exiſtence, not from any idea of him, but from our reaſoning, upon the works of the viſible creation. And hence, for want of a ſimple and direct idea, we form an indirect and very complex notion of him.

This we do in the beſt manner we can, by removing from him all the imperfections of the creatures, and attributing to him all their perfections, eſpecially thoſe of our own minds. Yet in truth, even theſe cannot be ſuppoſed to be in God, as they are in us. And therefore we are ſaid to aſcribe them to him only in the abſtract: which is ſaying in other words, that they are of a different ſpecies in the Creator, from what they are in the creature.

Accordingly, that there are incomprehenſible perfections in God, anſwerable to knowledge and power in man, whereof theſe are only the faint, though true, reſemblances, is natural and eaſy to conceive. But the conceiving his power as an ability to change things infinitely, his knowledge as only infinite thinking; the multiplying and enlarging our own perfections in number or degree only, to the utmoſt ſtretch of our capacity, and attributing them ſo enlarged to God, is no more than raiſing up an unwieldy idol of our own imagination, without any foundation in nature.

The ſum is this. We have no idea of God, as he is in himſelf. For want of one, we frame the beſt conception we can, by putting together the perfections of the creatures, particularly thoſe we obſerve in ourſelves,

to

to ſtand for his perfections: not groſsly inferring, that God is, in effect, ſuch an one as ourſelves; but, concluding, that our greateſt excellencies are the apteſt repreſentations of his incomprehenſible perfections, though theſe infinitely tranſcend the moſt exalted of what are in any created beings, and are far above, out of the reach of all human imagination. So true it is, that, though it may be juſtly affirmed, we can have no knowledge without ideas, yet it is moſt unjuſt and abſurd to infer thence, that we can have no knowledge beyond them.

SECT. III.

The Properties of Ideas of Sensations.

SINCE then the ideas of ſenſation are the foundation, and rough materials, of all even our moſt abſtracted knowledge, (out of which every man raiſes a ſuperſtructure, according to the different turn of thoſe organs, that are more immediately ſubſervient to the operations of the underſtanding, and the different ways in which he employs thoſe operations;) it will be convenient to ſay ſomething concerning the properties of theſe ideas.

Their firſt property is, that they are original. We receive them from our firſt coming into the world, without any immediate concurrence of the underſtanding, antecedently to any of its operations. The ſoul, till theſe are received, is wholly inactive, and cannot ſo much as form one thought. Theſe ideas are, in reſpect of our ſubſequent notions, like the firſt particles of matter in reſpect to the things compounded of them. They run through infinite changes, as the mind works upon them; yet in themſelves remain unchangeable. And as our compound notions are made out of theſe, ſo are they all ultimately reſolvible into them.

Ideas of ſenſation are by this property diſtinguiſhed,

1. From ſuch ideas, as are ſuppoſed to be innate, and antecedent to the impreſſion of any outward object.

That

That we have no ſuch ideas, ſufficiently appears even from hence, that we have no occaſion for them. We have no occaſion for innate ideas of ſenſible objects, becauſe there is an obvious way of obtaining them by the ſenſes. And as to our knowledge of ſpiritual things, as it cannot be accounted for by innate ideas, ſo it eaſily may be accounted for without them. The riſe and whole extent of this knowledge is eaſily accounted for, from the ideas we have of ſenſible objects, the neceſſary conſequence we draw from their exiſtence, to the exiſtence of things not ſenſible, and from that manner of conceiving theſe, which we naturally fall into, by the help and mediation of ſuch things, as are within our preſent ſphere.

2. From ſuch ideas as are ſuppoſed to be acquired by, and ſeated in the underſtanding, to be the groundwork of our knowledge of ſpiritual things, as others are of our knowledge of things material. Now, if there were any ſuch ideas, we muſt acquire them one of theſe ways: either,

Firſt, By the preſence of the object itſelf, and its immediate impreſſion on ſome faculty diſpoſed to receive and retain the impreſſion. But every one may be conſcious, that immaterial objects were never ſo preſent to any faculty of his mind, as to imprint and leave upon it any juſt and real ſimilitude or reſemblance of themſelves. Or,

Secondly, Theſe ideas muſt proceed from the immediate power of God. That he can impregnate the mind with them, is certain. But how is it proved, that he does? If ever he does, it is by an extraordinary, ſupernatural act. Whereas we are now ſpeaking of what our perceptions are, in the ordinary way of nature. Or,

Thirdly, The mind has a power of raiſing up to itſelf ideas of things, whereof it can have no actual view, of objects which have no communication with any of our faculties. But if it cannot form one idea of any material object, without the actual preſence of it, much leſs can it frame ideas of immaterial objects, without their immediate preſence.

Perhaps the power of raiſing up to itſelf ideas, without

without the preſence or impreſſion of any object, is the privilege of the Divine Mind, anſwerable to that of creation. But the power of our mind in the little world, is much the ſame with that of the whole man in the greater. It is as impoſſible for it to raiſe up to itſelf any new idea, independent of all ſenſation, as it is for a man to add one particle to the common maſs of matter.

A ſecond property of an idea of ſenſation is, that it is ſimple: by which I mean, that it is an appearance, which cannot be reſolved into more than one of the ſame kind.

Simple ideas are generally confined within too narrow a compaſs. For not only thoſe of ſounds, ſmells, taſtes, colours, and tangible qualities, are ſimple, but the ideas of all ſingle bodies. All that ſtrikes the ſenſe at once, is to be accounted a ſimple idea. For you cannot divide the idea you have of any one body, into the idea of more bodies than one; though it may be ſubdivided into the ideas of the ſeveral parts of that body.

By this property, ideas of ſenſation are diſtinguiſhed,

1. From the various alterations and combinations of them made by the mind. The mind cannot indeed deſtroy any of theſe ideas, any more than it could create them. But it alters, enlarges or diminiſhes them: it ſeparates and tranſpoſes them; and thus is furniſhed with a new ſet of ideas from within, as well as with ſimple ones from without.

2. From thoſe notions, which the underſtanding forms out of ſimple and complex ideas, conſidered together with the various operations of the underſtanding upon them. Such is the notion we form of moſt virtues and vices: each of which is apprehended by ideas of ſenſation, and the action of the mind upon them put together into one complex conception.

A third property of ideas of ſenſation is, that they are direct and immediate. Theſe original, ſimple ideas neceſſarily preſuppoſe the preſence of the object, and its actual impreſſion on the ſenſe: whence follows a direct and immediate repreſentation of it, without the

the intervention of any thing elſe. Thus we could not have had the idea of a tree, if the eye had not actually ſeen it; nor of a trumpet's ſound, if ſome of the undulating air had not actually ſtruck upon the ear.

By this property, ideas of ſenſation are diſtinguiſhed,

1. From the ideas we have of thoſe objects of the ſame kind, which we never actually perceived. Thus the idea of a man we have ſeen, is put for a man we never ſaw: having no way of conceiving of a man that was never preſent, but by ſubſtituting for him the idea of one that was.

2. From all conceptions of things, which are purely metaphorical. There are two ſorts of metaphor, human and divine.

Divine metaphor is the ſubſtituting our ideas of ſenſation, which are direct and immediate with the words belonging to them, for the things of heaven, of which we have no direct idea, or immediate conception; as when God's knowledge is expreſſed by his being in every place, his power, by a ſtrong hand.

Divine and human metaphor agree in this, that the words, figuratively transferred from one thing to another, do not agree with the things to which they are transferred, in any part of their literal ſenſe. So hands and eyes, when applied to God, are not ſpoke in any part of their literal ſignification: as neither is the word ſmiling, when applied to the verdure of a field.

They differ in this, that in human metaphor the things, for which the figurative words are ſubſtituted, may be as immediately and directly known, as the ideas placed in their ſtead. But in divine metaphor, only the ſubſtituted ideas are direct and immediate. We have no direct or immediate conception of the things they are ſubſtituted for.

3. From all conceptions of things, which are purely analogical. Divine analogy is the ſubſtituting words, that expreſs our ideas, for heavenly things, whereof we have no ideas. Thus far it agrees with metaphor: but here lies the eſſential difference. Metaphorical

words

words are ſpoke of heavenly things, in no part of their proper ſenſe: analogical, in ſome part of it, though not the whole. So the word hand is ſpoken of God metaphorically: for he has no hand of any ſort whatever. The word power is ſpoken of him analogically: for he has ſome ſort of power, though of a quite different ſort from ours.

The true nature of our preſent knowledge of divine things, is by the apoſtle very aptly deſcribed by our ſeeing in a glaſs darkly, or in a mirror, in an obſcure repreſentation. To ſhew the aptitude and ſignificancy of which expreſſions, I ſhall obſerve two things:

1. That a glaſs exhibits to us nothing of the ſubſtance of the thing repreſented in it: the ſimilitude therein having no more of the eſſence of the thing itſelf, than a mere ſhadow. Yet we cannot ſay, but there is a real likeneſs of the ſubſtance in the airy form. There is ſuch a proportion between them, that the idea of a face we never ſaw, but in a glaſs, is a juſt one, and may well be ſubſtituted for the face itſelf, of which it gives ſome real knowledge.

Thus as to thoſe conceptions, which ſtand in our minds to repreſent ſpiritual things, though the things they ſtand for are of quite another ſort, and though theſe ſubſtitutes are no more in reſpect of them, than a fleeting appearance in the glaſs is to the man repreſented by it; yet there may be ſuch a proportion between them, as to make our conceptions of natural things juſt repreſentations of things ſupernatural. So that the knowledge we have of them is true, and our reaſonings upon them ſubſtantial, as long as they are kept within the due compaſs of thoſe repreſentations. For then it is, that men run into abſurdity, concerning ſpiritual things, when, not content with this analogical knowledge, they argue from things natural to the intrinſic nature of the ſupernatural, and ſuppoſe, that what is affirmed of theſe repreſentations only, is literally true of the things they repreſent.

The ſecond thing I would obſerve concerning this phraſe is, that in all inſtances we uſe the ſame expreſſions, by which we expreſs the things themſelves, for their appearances in the glaſs. And indeed juſtly:

for though there is nothing of the real nature of the objects, in thoſe appearances, yet, ſeeing there is ſuch a proportion between them, the ſame words aptly ſerve for both. So we ſay, we ſee a man in the glaſs, or the ſun or moon in the water, when we ſee only an appearance, which has nothing of the real nature of a man, or the ſun or moon. And there is ſuch a proportion between the object and its appearance, as would give us ſome idea of it, though we had never ſeen it, but in a glaſs, or in the water.

By what has been already ſaid, analogy in general may be eaſily diſtinguiſhed from metaphor. But becauſe the diſtinction between this and divine analogy is of ſo great importance, I ſhall ſet the difference between theſe two in a clearer and oppoſite light.

Metaphor expreſſes an imaginary, analogy a real correſpondence: metaphor is no more than an alluſion; analogy, a ſubſtitution of ideas and conceptions. The intention of metaphor is only, to expreſs more omphatically ſomething known more exactly before: the intention of analogy, to inform us of ſomething, which we could not have known without it. Metaphor uſes ideas of ſenſation to expreſs things, whereto they have no real reſemblance: analogy ſubſtitutes our notions and complex conceptions for things, with which they have a real correſpondence. To conclude. Words applied metaphorically are not underſtood in any part of their proper ſenſe: analogical words are underſtood in a part, though not the whole of their literal meaning.

CHAP.

CHAP. II.

SECT. I.

Of the pure Intellect and its Operations.

HAVING hitherto conſidered the ideas of ſenſation as the only materials the mind of man has to work upon, I come to treat of the mind itſelf, or the Pure Intellect. I do not mean by this, the immaterial part of us, nor yet the moſt refined and exquiſite parts of the body, which are immediately ſubſervient to its nobler operations: but both of theſe operating together in eſſential union.

Our preſent knowledge is gradually performed, by the concurrent motion of ſome bodily part within us; which is the cauſe of that wearineſs we feel, after long-continued thinking. We ſhould never be tired with this, if the pure ſpirit could reaſon independently of all material organs. But experience ſhews us, the caſe is otherwiſe: we find it a labour to the brain, and feel ourſelves as much wearied with intenſe thought, as with hard bodily labour: having premiſed this of them in general, I proceed to conſider the particular operations of the intellect, which preſuppoſe ſenſation, and contain the whole proceſs and utmoſt extent of human underſtanding.

The firſt of theſe is a ſimple view or ſurvey of the ideas of ſenſation, juſt as they lie in the memory. This the Logicians have rightly termed ſimple apprehenſion; but they generally confound it with pure ſenſation, whereas it is eaſy to obſerve theſe eſſential differences between them. 1. In ſimple apprehenſion the mind is often active, in ſenſation always paſſive: 2. Simple apprehenſion preſuppoſes ſenſation, and is al-

ways ſubſequent to it: 3. By ſenſation the mind receives ideas; by ſimple apprehenſion ſhe ſurveys thoſe already received.

The ſecond operation of the intellect on the ideas of ſenſation is judgment. This may be divided into ſeveral ſpecies; the moſt conſiderable of which are theſe that follow.

1. The ſeparating our ideas from each other, and ranging them under diſtinct heads.

2. The comparing them with each other, and obſerving their agreements or diſagreements.

3. The enlarging or diminiſhing them. So we can enlarge the idea we have of a tree, to any ſize, even to reach the clouds; or diminiſh it in our thoughts, till we reduce it to what it was in its firſt principle or ſeed.

4. The dividing or compounding them. So we divide any ſimple idea into its ſeveral parts, or compound the ideas of ſeveral houſes, to make up that of a city. All theſe ſpecies of judging are peculiar to men, and not enjoyed by brutes in any degree.

Another act of the intellect, generally reduced to judgment, is abſtraction. This ſome ſuppoſe to be performed, by drawing the mind off from all ideas of ſenſation, from all compoſitions of them, and from all complex notions, in order to form ideas of incorporeal beings. But it may be doubted, whether this be practicable in our preſent ſtate.

The true abſtraction ſeems to conſiſt, not in forming ideas independent on ſenſation, but in ſubſtituting the only notions we have, which are natural, eaſy, and familiar, to repreſent thoſe ſupernatural things, of which otherwiſe we can have no notion; in transferring our thoughts from the literal propriety of the words, by which we expreſs them, to that analogical ſignification, whereby they are, as it were ſpiritualized. This ſeems to be the only abſtraction we are capable of, with regard to things ſpiritual. And this is ſo far from being independent on ſenſation, and the operations of the intellect, that we can no otherwiſe think or ſpeak of ſuch objects, than in theſe worldly and human ſymbols; and that, if we abſtract from theſe, we abſtract from

all

all thought of heavenly beings, and can have neither names nor ideas for them.

What has been hitherto ſaid of the operations of the intellect, relates only to ideas of ſenſation. Therefore it is proper to obſerve here, that the ſame operations are likewiſe exerciſed upon all our alterations and compoſitions of them. When the memory is once furniſhed with thoſe voluntary alterations and combinations of ſimple ideas, the mind has the ſame full power over them, as over the ground-work of them; namely, that of ſimple apprehenſion, and of judgment in all its branches. And the ſame arbitrary ſway it has over all the complex notions and conceptions, which are formed out of thoſe ſimple or complex ideas, conſidered together with the operations of the intellect upon them.

Before we cloſe this head of judgment, it is worth while to take particular notice of that ſpecies of one of its branches, comparing, which is diſtinct from all the reſt, and is commonly called relation. This is that act of the mind, whereby it conſiders the dependencies of things on each other. I ſhall dwell on it no longer, than is neceſſary to ſhew the procedure of the underſtanding, in attaining knowledge.

Firſt, When we conſider the relations of ſenſible objects to each other, as they are in their own nature, without any reſpect which they bear to our underſtanding, hence opens a ſpacious field of knowledge; that of natural cauſes and effects, of the manner wherein natural things act upon, or ſuffer from, each other: in ſhort, of their influencing one another numberleſs ways: and this is Natural Philoſophy.

Secondly, From our ideas of ſenſation, we infer the exiſtence of thoſe outward objects, that occaſion them in us. And from the exiſtence of theſe we infer a firſt cauſe of all things, eternal, and neceſſarily exiſting. Hence again we have the knowledge of the relation he bears to us, as our Creator and our Preſerver. From theſe relations flow all the duties of piety; ſuch as love, reverence, praiſe, and prayer.

Again. When we conſider the relation we bear to our fellow-creatures, of the ſame nature and degree

in

in this world, hence we come to be ſenſible of our obligations to juſtice and humanity. And when we diſtinguiſh theſe by particular, nearer relations, ſuch as parent or child, ſervant or maſter, hence we deduce all the duties neceſſary to the well-being of the whole kind, and of every individual.

Laſtly, When we conſider the relation we bear to ourſelves, the regard every man ought to have for his own happineſs; hence we may infer all thoſe duties, that naturally tend to promote the good either of our body or mind. And all comprehended under this ſecond head, is properly natural religion. For the ſanction of this, and to ſhew the tendency of its precepts to our future happineſs, the underſtanding proceeds thus. From the unequal diſtribution of rewards to thoſe, who obſerve them, and of puniſhments to thoſe, who tranſgreſs them in this life, ſo evidently inconſiſtent with the goodneſs and juſtice of an All-perfect Being, we infer the neceſſity of future rewards and puniſhments, and conſequently the immortality of human ſouls.

SECT. II.

Of the different Kinds of Knowledge and Evidence.

IT being a matter of the utmoſt conſequence to the right procedure of the intellect, to ſtate the ſeveral kinds of knowledge, as well as the degrees of it in each kind, which can admit of any, I ſhall obſerve, that there are three kinds of knowledge, and as many kinds of evidence, on which they are built.

The firſt is that we have from our ſenſes, which conſiſts in an intellectual view of the ideas tranſmitted through them to the memory. This is a knowledge direct, immediate, and intuitive, and carries in it the higheſt certainty. Conſequently, it admits of no proof from reaſon: for all ſuch proof has leſs of perſpicuity and certainty, than that which it already contains in its own nature. This is a knowledge, which admits of no degrees of evidence: for all ſenſation is in itſelf equally

equally certain, and the evidence of all the ſenſes is equally clear, with reſpect to their proper objects. When the ſenſation is regular, and perfect, the aſſent of the intellect neceſſarily follows all at once; though in a manner quite different from demonſtration, which extorts it by intermediate proof. Not that it yields to the cleareſt demonſtration, when the organ is rightly diſpoſed, and exerciſed upon its proper object, at a juſt diſtance, and in a due medium. Againſt ſenſitive knowledge, reaſon can never interpoſe, unleſs there is a ſuſpicion of failure in the act of ſenſation. Nor does it inquire then, whether the evidence of ſenſe be true; but whether it be truly the evidence of ſenſe. So that to argue againſt the evidence of ſenſe, is to oppoſe the evidence of reaſon, to what in its nature admits of no reaſoning at all.

And highly neceſſary it was, that this evidence of ſenſe ſhould be ſo immediate, clear, and undoubted, becauſe it is the foundation of all knowledge, human and divine. If then the truth of this admitted of any doubt, or were capable of any proof, we ſhould wander about in endleſs ſcepticiſm, without the leaſt certainty in any thing. For no proof for it could be more evident, than that which it was brought to prove, and would therefore itſelf require another proof; and ſo on, with endleſs confuſion.

A ſecond kind of knowledge is that we have from ſelf conſciouſneſs. We come to the knowledge of things without us, by the mediation of their ideas; but we are immediately conſcious of what paſſes in our own minds, without the intervention of any idea. Thus we have a knowledge of all the faculties of our ſoul, very different from ſenſitive knowledge; though we have no degree of it antecedent to the exerciſe of thoſe faculties upon the ideas of ſenſation: as we ſhould have had no knowledge of our bodily motions, if the parts had not been actually moved.

Though this kind of knowledge be more complex, it is equally certain with that we have from ſenſation. The aſſent as neceſſarily follows upon conſciouſneſs: indeed it falls in with it. The conſciouſneſs itſelf is the very aſſent; nor can they be diſtinguiſhed even in thought.

in this world, hence we come to be ſenſible of our obligations to juſtice and humanity. And when we diſtinguiſh theſe by particular, nearer relations, ſuch as parent or child, ſervant or maſter, hence we deduce all the duties neceſſary to the well-being of the whole kind, and of every individual.

Laſtly, When we conſider the relation we bear to ourſelves, the regard every man ought to have for his own happineſs; hence we may infer all thoſe duties, that naturally tend to promote the good either of our body or mind. And all comprehended under this ſecond head, is properly natural religion. For the ſanction of this, and to ſhew the tendency of its precepts to our future happineſs, the underſtanding proceeds thus. From the unequal diſtribution of rewards to thoſe, who obſerve them, and of puniſhments to thoſe, who tranſgreſs them in this life, ſo evidently inconſiſtent with the goodneſs and juſtice of an All-perfect Being, we infer the neceſſity of future rewards and puniſhments, and conſequently the immortality of human ſouls.

SECT. II.

Of the different Kinds of Knowledge and Evidence.

IT being a matter of the utmoſt conſequence to the right procedure of the intellect, to ſtate the ſeveral kinds of knowledge, as well as the degrees of it in each kind, which can admit of any, I ſhall obſerve, that there are three kinds of knowledge, and as many kinds of evidence, on which they are built.

The firſt is that we have from our ſenſes, which conſiſts in an intellectual view of the ideas tranſmitted through them to the memory. This is a knowledge direct, immediate, and intuitive, and carries in it the higheſt certainty. Conſequently, it admits of no proof from reaſon: for all ſuch proof has leſs of perſpicuity and certainty, than that which it already contains in its own nature. This is a knowledge, which admits of no degrees of evidence: for all ſenſation is in itſelf

equally

equally certain, and the evidence of all the ſenſes is equally clear, with reſpect to their proper objects. When the ſenſation is regular, and perfect, the aſſent of the intellect neceſſarily follows all at once; though in a manner quite different from demonſtration, which extorts it by intermediate proof. Not that it yields to the cleareſt demonſtration, when the organ is rightly diſpoſed, and exerciſed upon its proper object, at a juſt diſtance, and in a due medium. Againſt ſenſitive knowledge, reaſon can never interpoſe, unleſs there is a ſuſpicion of failure in the act of ſenſation. Nor does it inquire then, whether the evidence of ſenſe be true; but whether it be truly the evidence of ſenſe. So that to argue againſt the evidence of ſenſe, is to oppoſe the evidence of reaſon, to what in its nature admits of no reaſoning at all.

And highly neceſſary it was, that this evidence of ſenſe ſhould be ſo immediate, clear, and undoubted, becauſe it is the foundation of all knowledge, human and divine. If then the truth of this admitted of any doubt, or were capable of any proof, we ſhould wander about in endleſs ſcepticiſm, without the leaſt certainty in any thing. For no proof for it could be more evident, than that which it was brought to prove, and would therefore itſelf require another proof; and ſo on, with endleſs confuſion.

A ſecond kind of knowledge is that we have from ſelf conſciouſneſs. We come to the knowledge of things without us, by the mediation of their ideas; but we are immediately conſcious of what paſſes in our own minds, without the intervention of any idea. Thus we have a knowledge of all the faculties of our ſoul, very different from ſenſitive knowledge; though we have no degree of it antecedent to the exerciſe of thoſe faculties upon the ideas of ſenſation: as we ſhould have had no knowledge of our bodily motions, if the parts had not been actually moved.

Though this kind of knowledge be more complex, it is equally certain with that we have from ſenſation. The aſſent as neceſſarily follows upon conſciouſneſs: indeed it falls in with it. The conſciouſneſs itſelf is the very aſſent; nor can they be diſtinguiſhed even in thought.

thought. When this internal ſenſation is truly natural, we are never deceived in this article of knowledge. And this alſo is ſo clear and diſtinct, that it admits of no proof from reaſon. So that neither can this, any more than the former, be called demonſtration: ſince, like that, it is ſo immediate and intimate to us, that nothing can increaſe its evidence. And for a man to argue away any inſtances of this knowledge, or to deny their certainty, is no leſs abſurd, than to contradict the clear perceptions of external ſenſe. Only it is to be obſerved, that all here ſaid of this knowledge, is ſaid of the firſt, immediate, internal perceptions; not of any farther obſervations, made upon them by the intellect, or of any deductions afterwards drawn concerning them.

Theſe two kinds of knowledge are immediate, and conſequently a ſort of intuition; entirely different from which is,

The third kind of knowledge, reaſoning, which is mediate, and wholly acquired by deduction, by the exerciſe of that one operation of the mind, illation or conſequence. This we may ſubdivide into different ſpecies, according to the different manner of the intellect's procedure, in making its deductions.

The firſt ſpecies is ſcience or demonſtration, which appears cleareſt in the ſyllogiſtic form; by applying a common meaſure to two extremes, which have an infallible connexion with it. So that the concluſion follows by an abſolute certainty, and compels the aſſent. And the knowledge is as infallible, as the direct, clear perception of ſenſation, or conſciouſneſs.

The ſecond ſpecies of it is moral certainty, the utmoſt degree of which is neareſt to demonſtration. This knowledge is acquired by proofs, that have only an undoubted connexion with the two extremes. The force of this every plain underſtanding perceives; and it rarely requires the ſyllogiſtic form, unleſs for the confuting perverſe oppoſers. The arguments for it are deduced from all kinds of knowledge: but ſtill the aſſent is free; and the will has a great ſhare in promoting or hindering it. And hence it comes, that

there

there is room for paſſion and prejudice of all ſorts, to interpoſe and bias the intellect.

We ought not therefore to call the evidence of moral truths, by the name of demonſtration. It is true, both mathematical and moral truths are founded on the ſtrongeſt proofs. Yet they admit not of the ſame ſort of proof, nor indeed are they capable of it.

Becauſe it is ſo great a diſadvantage both to natural and revealed religion, to have a moral certainty confounded with mathematical, I ſhall diſtinguiſh the different natures of them more fully, under two different propoſitions.

Mathematical Certainty.	Moral Certainty.
As in this propoſition, the three angles of a right-lined triangle are equal to two right ones.	As in this propoſition, there is a God.
1. Here there is the utmoſt degree of mathematical certainty: the evidence is infallible, and the conſequence follows by a natural neceſſity.	1. Here there is the utmoſt degree of moral certainty: the evidence is indubitable, and the conſequence follows by a moral neceſſity.
2. The demonſtrative evidence of this, when underſtood, compels and extorts aſſent.	2. The moral evidence of this, when underſtood, demands and requires aſſent.
3. In this point of knowledge, no concurrence of the will is requiſite. The intellect aſſents without it, and no prejudice or paſſion can ſo interpoſe, as to influence its judgment.	3. In this point of knowledge, the concurrence of the will is requiſite. The intellect cannot aſſent without it. Any prejudice or paſſion may ſo interpoſe, as entirely to alter its judgment.
4. This ſort of knowing admits of no degrees of certainty, and there can be no proof of it, but of one kind.	4. This ſort of knowledge admits of many degrees of certainty, and draws its proofs from all kinds of knowledge.

5. One demonſtrative argument makes the utmoſt mathematical certainty, which excludes all poſſibility of falſehood.	5. Many arguments concur to make the utmoſt moral certainty, which excludes all probability, though not poſſibility, of falſehood.
6. This takes place in things natural and material, ſuch as quantity, figure, and extenſion; ideas of which we have from direct and immediate ſenſation.	6. This takes place in things ſupernatural and ſpiritual, ſuch as God and his attributes; of which we have no idea from direct and immediate ſenſation, but only from analogy.
7. Our reaſonings on this ſide are about ſimple ideas, concerning which there is general conſent.	7. Our reaſonings on this ſide are about complex notions and conceptions, concerning which men extremely diſagree.

From the very different, and even oppoſite nature of moral certainty, and that which is ſtrictly mathematical, it muſt appear,

1. That there is as little room for the latter in natural religion, as in revealed. To ſhew this clearly, I have inſtanced in the fundamental truth of both; which, though founded upon the utmoſt moral evidence, ſo as to render a diſſent from it inexcuſable, yet appears not to be ſtrictly demonſtrable. Indeed, were there one demonſtrative argument for it, all others would be entirely needleſs.

2. That natural religion includes faith founded on moral evidence. When, upon full proof to our underſtanding, we aſſent to this, there is a God, then the hearty concurrence of the will completes that aſſent into faith. Faith therefore is altogether as neceſſary in natural religion, as in revealed. For though we have a moral certainty for the exiſtence of a Deity, which ſo far is knowledge only; yet ſtill becauſe the intrinſic nature of God is utterly incomprehenſible, and can be no immediate object of human underſtanding, men muſt give the aſſent of the intellect here,

together

together with the conſent of the will, to the truth of things as myſterious, as any in all revealed religion; and which they are obliged to conceive by the ſame analogy, by which we conceive all the myſteries of chriſtianity.

3. That evangelical faith is no precarious or implicit aſſent, but founded on the utmoſt evidence we are capable of receiving, for a truth of that nature. To ſee this clearly, we muſt well diſtinguiſh two things:

Firſt, The aſſent of the underſtanding to a propoſition upon moral evidence, which is thus far merely knowledge. Here we are to fix our foot, and join iſſue with all ranks of unbelievers; the ground of whoſe condemnation will be, that they wilfully withheld their aſſent from the truths of revelation, when they had the ſame evidence, which would have fully convinced them in matters merely human.

Secondly, A conſent of the will, following the aſſent of the intellect. The whole proceſs of the mind, in obtaining ſuch a faith, is performed in this manner. 1. A propoſition being offered to us, the will conſents to weigh the evidence for it. 2. The intellect weighs it, and if the moral evidence be full, aſſents to it. Thus it commences a point of knowledge, and on a ſecond conſent of the will, a point of faith.

But it is worth obſerving, that there can be no immediate aſſent, to any thing inconceivable or incomprehenſible. To explain this by a few inſtances. "There is a God." When, upon full evidence, we aſſent to this, what is intelligible in that propoſition, is the immediate object of our knowledge. The incomprehenſible nature and attributes of God are only the remote and mediate objects of it.

Again. "This is my beloved Son." We aſſent to this, as a perfectly intelligible propoſition, on full evidence that it was ſpoke from heaven; being aſſured, that Chriſt, not in any unintelligible manner, but according to the plain ſenſe of the word, is as really and truly the Son of God, as one man is the ſon of another.

He who believes thus far, without any reſpect to what is incomprehenſible in that propoſition, namely, the

thought. When this internal ſenſation is truly natural, we are never deceived in this article of knowledge. And this alſo is ſo clear and diſtinct, that it admits of no proof from reaſon. So that neither can this, any more than the former, be called demonſtration: ſince, like that, it is ſo immediate and intimate to us, that nothing can increaſe its evidence. And for a man to argue away any inſtances of this knowledge, or to deny their certainty, is no leſs abſurd, than to contradict the clear perceptions of external ſenſe. Only it is to be obſerved, that all here ſaid of this knowledge, is ſaid of the firſt, immediate, internal perceptions; not of any farther obſervations, made upon them by the intellect, or of any deductions afterwards drawn concerning them.

Theſe two kinds of knowledge are immediate, and conſequently a ſort of intuition; entirely different from which is,

The third kind of knowledge, reaſoning, which is mediate, and wholly acquired by deduction, by the exerciſe of that one operation of the mind, illation or conſequence. This we may ſubdivide into different ſpecies, according to the different manner of the intellect's procedure, in making its deductions.

The firſt ſpecies is ſcience or demonſtration, which appears cleareſt in the ſyllogiſtic form; by applying a common meaſure to two extremes, which have an infallible connexion with it. So that the concluſion follows by an abſolute certainty, and compels the aſſent. And the knowledge is as infallible, as the direct, clear perception of ſenſation, or conſciouſneſs.

The ſecond ſpecies of it is moral certainty, the utmoſt degree of which is neareſt to demonſtration. This knowledge is acquired by proofs, that have only an undoubted connexion with the two extremes. The force of this every plain underſtanding perceives; and it rarely requires the ſyllogiſtic form, unleſs for the confuting perverſe oppoſers. The arguments for it are deduced from all kinds of knowledge: but ſtill the aſſent is free; and the will has a great ſhare in promoting or hindering it. And hence it comes, that

there

there is room for paſſion and prejudice of all ſorts, to interpoſe and bias the intellect.

We ought not therefore to call the evidence of moral truths, by the name of demonſtration. It is true, both mathematical and moral truths are founded on the ſtrongeſt proofs. Yet they admit not of the ſame ſort of proof, nor indeed are they capable of it.

Becauſe it is ſo great a diſadvantage both to natural and revealed religion, to have a moral certainty confounded with mathematical, I ſhall diſtinguiſh the different natures of them more fully, under two different propoſitions.

Mathematical Certainty.	Moral Certainty.
As in this propoſition, the three angles of a right-lined triangle are equal to two right ones.	As in this propoſition, there is a God.
1. Here there is the utmoſt degree of mathematical certainty: the evidence is infallible, and the conſequence follows by a natural neceſſity.	1. Here there is the utmoſt degree of moral certainty: the evidence is indubitable, and the conſequence follows by a moral neceſſity.
2. The demonſtrative evidence of this, when underſtood, compels and extorts aſſent.	2. The moral evidence of this, when underſtood, demands and requires aſſent.
3. In this point of knowledge, no concurrence of the will is requiſite. The intellect aſſents without it, and no prejudice or paſſion can ſo interpoſe, as to influence its judgment.	3. In this point of knowledge, the concurrence of the will is requiſite. The intellect cannot aſſent without it. Any prejudice or paſſion may ſo interpoſe, as entirely to alter its judgment.
4. This ſort of knowing admits of no degrees of certainty, and there can be no proof of it, but of one kind.	4. This ſort of knowledge admits of many degrees of certainty, and draws its proofs from all kinds of knowledge.

5. One demonſtrative argument makes the utmoſt mathematical certainty, which excludes all poſſibility of falſehood.	5. Many arguments concur to make the utmoſt moral certainty, which excludes all probability, though not poſſibility, of falſehood.
6. This takes place in things natural and material, ſuch as quantity, figure, and extenſion; ideas of which we have from direct and immediate ſenſation.	6. This takes place in things ſupernatural and ſpiritual, ſuch as God and his attributes; of which we have no idea from direct and immediate ſenſation, but only from analogy.
7. Our reaſonings on this ſide are about ſimple ideas, concerning which there is general conſent.	7. Our reaſonings on this ſide are about complex notions and conceptions, concerning which men extremely diſagree.

From the very different, and even oppoſite nature of moral certainty, and that which is ſtrictly mathematical, it muſt appear,

1. That there is as little room for the latter in natural religion, as in revealed. To ſhew this clearly, I have inſtanced in the fundamental truth of both; which, though founded upon the utmoſt moral evidence, ſo as to render a diſſent from it inexcuſable, yet appears not to be ſtrictly demonſtrable. Indeed, were there one demonſtrative argument for it, all others would be entirely needleſs.

2. That natural religion includes faith founded on moral evidence. When, upon full proof to our underſtanding, we aſſent to this, there is a God, then the hearty concurrence of the will completes that aſſent into faith. Faith therefore is altogether as neceſſary in natural religion, as in revealed. For though we have a moral certainty for the exiſtence of a Deity, which ſo far is knowledge only; yet ſtill becauſe the intrinſic nature of God is utterly incomprehenſible, and can be no immediate object of human underſtanding, men muſt give the aſſent of the intellect here,

together

together with the conſent of the will, to the truth of things as myſterious, as any in all revealed religion; and which they are obliged to conceive by the ſame analogy, by which we conceive all the myſteries of chriſtianity.

3. That evangelical faith is no precarious or implicit aſſent, but founded on the utmoſt evidence we are capable of receiving, for a truth of that nature. To ſee this clearly, we muſt well diſtinguiſh two things:

Firſt, The aſſent of the underſtanding to a propoſition upon moral evidence, which is thus far merely knowledge. Here we are to fix our foot, and join iſſue with all ranks of unbelievers; the ground of whoſe condemnation will be, that they wilfully withheld their aſſent from the truths of revelation, when they had the ſame evidence, which would have fully convinced them in matters merely human.

Secondly, A conſent of the will, following the aſſent of the intellect. The whole proceſs of the mind, in obtaining ſuch a faith, is performed in this manner. 1. A propoſition being offered to us, the will conſents to weigh the evidence for it. 2. The intellect weighs it, and if the moral evidence be full, aſſents to it. Thus it commences a point of knowledge, and on a ſecond conſent of the will, a point of faith.

But it is worth obſerving, that there can be no immediate aſſent, to any thing inconceivable or incomprehenſible. To explain this by a few inſtances. "There is a God." When, upon full evidence, we aſſent to this, what is intelligible in that propoſition, is the immediate object of our knowledge. The incomprehenſible nature and attributes of God are only the remote and mediate objects of it.

Again. "This is my beloved Son." We aſſent to this, as a perfectly intelligible propoſition, on full evidence that it was ſpoke from heaven; being aſſured, that Chriſt, not in any unintelligible manner, but according to the plain ſenſe of the word, is as really and truly the Son of God, as one man is the ſon of another.

He who believes thus far, without any reſpect to what is incomprehenſible in that propoſition, namely,

the

the ſupernatural generation, and the ineffable manner of it, has an evangelical faith.

But what then, you will ſay, becomes of the myſteries of the goſpel? They are all laid up ſafe, out of our reach, to be the immediate objects of our knowledge, when we come to ſee face to face.

From hence it appears, that chriſtian faith is not an implicit aſſent to things unintelligible and unconceivable: ſince nothing, that is incomprehenſible, can come into any queſtion between us and unbelievers. We can have no controverſy, but about what is perfectly underſtood, as far as it is ſo; and concerning the moral evidence, upon which propoſitions, as clear as any in human language, are founded. Our controverſies turn wholly upon what is clear. As to what is incomprehenſible, in any propoſition, it can be no immediate, direct object, either of knowledge or of faith.

The third ſpecies of knowledge, which we have from reaſon, is opinion. This Plato well defines a medium between knowledge and ignorance. It is a ſort of knowledge, looſely ſpeaking, inferior to any of the foregoing, but approaching neareſt to that founded on moral evidence. Only whereas moral certainty, in its higheſt degree, leaves but a bare poſſibility of the thing's being otherwiſe; all opinion leaves room, more or leſs, for doubt, yea, for ſome fear of its being otherwiſe. But as for all the degrees between the higheſt moral certainty on one hand, and the loweſt probability on the other, theſe two ſorts of knowledge run into each other, and are not eaſily to be diſtinguiſhed.

This may be illuſtrated by a parallel, drawn from common mechaniſm. While you are offering the reaſons, for and againſt any morally-certain or probable propoſition, imagine yourſelf throwing them into the ſcales, and weighing them in a balance. If the balance inclines not at all to either ſide, there is no ſort of knowledge, but downright ignorance: the reaſons on each ſide deſtroy each other, ſo that the intellect cannot aſſent to either. And if there be any deciſion, it is the arbitrary impoſition and precarious act of the will. If, either from its natural weakneſs, or for want

of

of improvement, the intellect cannot find out reaſons, ſo that each ſcale preponderates in its turn, then it is a ſtate of doubt. If one ſcale preponderates but a little, and continues at a ſtay, ſo that the difference is barely diſcernible, it is then only a conjecture. But if this preponderancy is very plain, though there is weight enough on the other ſide, to keep the ſcale ſtill pendent, then it is properly probability or opinion. When, laſtly, the arguments are ſo ſtrong that one of the ſcales weighs to the ground, then it is moral certainty, and there is no reaſonable cauſe for any farther ſcrutiny. The propoſition then concludes as ſurely, though not ſo neceſſarily, as demonſtration; which admits of no weight whatever to be thrown into the oppoſite ſcale.

Of probability in general it may be obſerved,

1. That, while we are weighing a probable propoſition, there are two latent cauſes of deceit; the one in the intellect itſelf, which holds the balance; for if a man is ignorant or weak, ſo as not to diſcern the proper reaſons, he may be impoſed upon by falſe weights: the other in the will, when, inſtead of plain reaſon, a man throws his pride, or paſſion, or prejudice, into the ſcales. And theſe will, by the inviſible turn of a falſe balance, outweigh the ſtrongeſt arguments.

2. That the higher degrees of probability, in matters of religion, demand our aſſent. So they do in all other things. Where the difference is not great, between the oppoſite ſides of a queſtion, men ever cloſe with the greateſt appearance of truth, and that in all things of the greateſt moment. Nay, the main conduct of human life is governed by the higheſt probability: ſo that, in many inſtances, it would be downright madneſs, not to be determined by it. Yet,

3. Mere probability is not a ſufficient ground for religious faith. This muſt be built on certain knowledge, which opinion, properly ſpeaking, is not. Indeed the word is vulgarly taken for any aſſent, whether formed on probability, or moral certainty. And ſo, it is commonly ſaid, "A man is of ſuch an opinion," with regard to the very fundamentals of Chriſtianity. But this looſe way of ſpeaking ought never to be uſed, ſeeing

ing it has a tendency to betray unwary men, into a favourable judgment of ſuch principles, as are deſtructive of all religion.

The fourth ſpecies of knowledge, which we have from reaſoning, (if it be not rather a particular ſpecies of moral certainty) is an aſſent upon teſtimony: to make which truly knowledge, there muſt be a concurrence of our own reaſon in the following particulars:

1. Our own reaſon muſt judge of the ſubject-matter of the information, whether it be made in intelligible words. For no man can be informed, of what he cannot underſtand: there can be no revelation to us, concerning the intrinſic nature of things, that are incomprehenſible to us. And accordingly, no part of the Chriſtian revelation, concerning God and things ſupernatural, reaches farther than their exiſtence, and that lively analogy, under which they are repreſented; which is as plain, and obvious, and intelligible, as any thing in common life.

2. Our reaſon muſt convince us, that the matter of the information is poſſible, that it implies no contradiction. And if the information relates to things ſupernatural, this is a fundamental rule, to deduce no contradiction, but from what is plain and intelligible in every propoſition. Whence it follows, that ſuch abſurdities and contradictions, as ariſe from a compariſon of what is plain and intelligible, with what is incomprehenſible, in reſpect of their intrinſic natures, are all groundleſs and imaginary.

3. Our reaſon muſt judge concerning the ability and integrity of the informer. Information or teſtimony may be divided into human and divine. To human teſtimony we aſſent only ſo far, as it appears agreeable to truth. Yet this aſſent is very extenſive, and makes up the greateſt part of human knowledge. It takes in all we have of the hiſtory of mankind, all the accounts of whatever we have not ſeen ourſelves. And we acquieſce in all this, not as probable only, but as ſo much real knowledge; being an aſſent, which is founded on ſuch evidence, as often amounts to a moral certainty.

As to Divine information or revelation, reaſon, knowing

ing it to be divine, is already convinced, that it exceeds all human certainty. The only thing, therefore, which is to be convinced of here is,

4. That the revelation is Divine, or that the Scripture is of Divine authority. In order to this we may obſerve,

Firſt, that, as God has made men the immediate inſtruments of all thoſe revelations, ſo evangelical faith muſt be partly founded on human teſtimony. By men were both the Old and New Teſtament wrote: and, if we conſider them abſtracted from their Divine authority, they muſt be allowed to be of equal credibility, at leaſt, with all other ancient writings. Though we ſhould ſuppoſe them to be upon the foot of mere human teſtimony, yet would our knowledge of them be, at leaſt, of equal certainty, with that founded on any profane hiſtory. Now, if to this human, we add ſuch Divine teſtimony, as cannot be pretended for any other writings in the world, as the miracles of Chriſt and his Apoſtles; the concurrent completion of all the prophecies, from the beginning of the world, in him alone; the ſcriptures being the only book in the world, that gives us any account of the whole ſeries of God's diſpenſations toward man, from the creation for four thouſand years; the great exaltation of natural religion, viſible in every part of it; and laſtly, the providential care, ſo manifeſt in every age, for tranſmitting down ſeveral books, written at ſuch great diſtances of time one from another, and all of them from us; their being at this day ſo void of any material error, that in the infinite various readings, which have been carefully collected, there cannot be found one contrariety in any fundamental point of faith or practice: if theſe things, I ſay, are thoroughly conſidered, they give the ſcriptures ſuch a certainty, as no writing merely human can have, and are the greateſt evidence for the truth of them, which they are capable of receiving, without a continued, daily repetition of miracles. We may obſerve,

Secondly, That, as God has made men the immediate inſtruments of all his revelations, ſo he hath condeſcended to make uſe of human language, as well as

of

of our natural ideas and conceptions, for the clear and eaſy repreſentation of things ſupernatural, and otherwiſe incomprehenſible. Indeed the intrinſic nature of heavenly things could not otherwiſe have been revealed to us; ſeeing we had neither capacity to apprehend, nor language to expreſs it. Or had it been miraculouſly revealed to a particular man, yet it would not have been poſſible for him to utter it. This made it neceſſary to adapt all the Divine revelations to our natural way of thinking and ſpeaking. And accordingly we are not obliged to believe any doctrine, which is not plain and intelligible. All in Scripture, beyond this, is no immediate object of our faith, but belongs to another world; and we are at preſent to believe no more of it, than that it is incomprehenſible.

Nothing therefore is more abſurd, than the objections of unbelievers againſt the Chriſtian myſteries, as unintelligible; ſince Chriſtianity requires our aſſent to nothing, but what is plain and intelligible in every propoſition. Let every man firſt have a full conviction of the truth of each propoſition in the goſpel, as far only as it is plain and intelligible, and let him believe as far as he underſtands. Let him firmly believe, there is but one God, the object of any divine worſhip whatever; and think and ſpeak of him under that plain, ſcriptural diſtinction, of Father, Son, and Holy Ghoſt; leaving the incomprehenſible nature of that union and diſtinction, to the great Author of our faith himſelf. Let him believe Chriſt to be the only-begotten Son of God, in the obvious import of theſe words, and leave the manner of that inconceivable generation, to the veracity of God. Let him believe, that Chriſt did as truly make an atonement to God for us, as one man atones for another to a third perſon; and leave the unintelligible part of that divine operation, for the ſubject of future praiſe and contemplation. Let men, I ſay, believe as far as they thus clearly underſtand, without perplexing themſelves or others with what is incomprehenſible; and then they fulfil the whole purpoſe of God in all his revelations.

By thus carefully diſtinguiſhing the ſeveral kinds of knowledge and evidence, what endleſs confuſion may be

be prevented, in religious controverſies? Moſt of theſe have ariſen from ſuppoſing theſe heads of knowledge to differ in degree only, not in kind; and from confounding the different kinds of evidence, peculiar to each of them; from men's inſiſting upon the evidence proper to one kind of knowledge, for that of another, which will not admit of it; from oppoſing to each other the different kinds of knowledge, which can never interfere or claſh with each other; and laſtly, from not diſtinguiſhing between a blind, implicit aſſent to the teſtimony of another, and that faith, which implies a full, rational conviction of the truth of what is believed.

SECT. III.

Of the Improvement of Knowledge by Revelation.

WE have now brought the mind of man, by ſeveral ſteps, to the utmoſt knowledge, it can reach by its own faculties. Whatever is beyond that contained under the foregoing heads, is communicated to it from heaven.

When we obſerve, 1. The more particular and full diſcoveries of thoſe relations we had ſome knowledge of, by the light of nature *, and, 2. Thoſe relations we bear to God, and God to us, which are entirely new, and undiſcoverable by the light of nature; this knowledge includes the foundation and ſubſtance of all revealed religion.

As to the firſt. When to that general knowledge we have by the light of nature, of God, as the Creator of all things, it is revealed, that he ſpoke them into being, and created them by his Word; that he made man in particular out of the earth, and breathed into him a principle of a higher kind; that he was created in innocence, and in the image of God; and that from him all mankind deſcended.

* I believe all "the light of nature," ſo called, to flow from preventing Grace.

Again.

Again. When to the general relation of his Providence over us, it is more particularly revealed, that he upholdeth all things by the Word of his power; that in Him we live, move, and have our being; that not a ſparrow falls to the ground without Him; nay, that the hairs of our head are all numbered; and, laſtly, when his relation to us, as a Judge, is rendered more full and expreſs by theſe particulars, "that the eyes of the Lord are in every place, beholding the evil and the good; that He ſhall bring every work into judgment, with every ſecret thing, whether it be good or evil; that He hath appointed a day, in which He will judge the world:" and that, in order to this univerſal judgment, there ſhall be "a reſurrection of the dead, both of the juſt and of the unjuſt."

Again. When it is revealed, that there is but one God; in oppoſition to the multitude of heathen deities; that this God is a Spirit, that there is none good but He; that He only is wiſe, and his wiſdom is infinite; that he is Almighty, hath all power, is above all, the only Potentate, King of kings, and Lord of lords; that He is the Moſt High, the Lord of hoſts, who only hath immortality: theſe and ſuch like equally expreſs declarations, concerning the One God, are evident improvements of that knowledge, which we have by the light of nature.

Theſe expreſſions are all plain and intelligible, ſo that, when we uſe them, we know what we ſay. But as to the following expreſſions, concerning the One God, that he is "God of himſelf, Root, Principle, and Original;" that he is a "Pure Act, ſimple, undivided, Self-exiſtent, abſolutely ſupreme;" together with the words, "Subordinate, co-ordinate," and above all, his metaphyſical "Subſtance and eſſence:" theſe are not the language of revelation, eſpecially when uſed to explain the Unity of God; but affected terms, invented by men, to expreſs their ſeveral ſentiments of that Unity.

Can we ſufficiently lament the miſchief, which has been done by the rumbling of theſe, and ſuch like ſounding words, through whole volumes; to the confounding both the writer and the reader, and perplexing

ing that great article of our faith, the Trinity: which, as it lies in the ſcripture, is, ſo far, as we are to believe it, the plaineſt thing in the world? All this pompous affectation of being more knowing in the Chriſtian myſteries, than the ſcriptures can make men, tends only to propagate abſurd and inconſiſtent notions, which a plain rational man would be aſhamed of. Such as theſe,

That the Son of God was produced by an external act of the Father's power, but was not made or created:

That there are Three Perſons truly Divine; one of them the true God, the Second, truly God, the Third, no God at all.

That we may and muſt pay divine worſhip to Two Gods, and divine honour to a Third Perſon, who is no God:

That by the term Trinity we muſt mean, a Trinity of Two Gods, and a Divine Perſon, but no God.

Theſe and many ſuch poſitions are either expreſsly, or by plain conſequence, contained in ſome of our modern ſyſtems of religion, and are ſet down here, not as they are a total ſubverſion of the Chriſtian faith, but as they are a bold and arbitrary impoſition on the common ſenſe and reaſon of mankind.

The relation we bear to God as our Creator, which was partly diſcovered by the light of nature, is made nearer yet, and more dear and engaging, by that entirely new diſtinction in the One God, revealed to us under the different characters of Father, Son, and Holy Ghoſt, and by the unſpeakable bleſſings we derive, from their ſeveral offices and operations.

This diſtinction, utterly incomprehenſible in itſelf, could never have been known to men, but by revelation. Nor could we have conceived it in any degree, had it not been diſcovered to us, under the ſemblance of ſuch relations, as are familiar among men: as that of a Father and a Son, and the Spirit of a man, which is in him. And, if we admit this diſtinction at all, we muſt hold it to be ſo really founded in the Divine Nature, that we cannot think or ſpeak of it any otherwiſe, than as a perſonal diſtinction. For the Father, Son,

and,

and Holy Ghoſt, are, in reſpect of one another, thus diſtinguiſhed through the whole language of revelation: and, in reſpect of mankind, they are ever diſtinguiſhed by ſuch different operations, as we diſtinguiſh human perſons by. So that whatever is denoted by Father, Son, and Spirit, we muſt either flatly reject the ſcriptures, or elſe always ſpeak and think of thoſe Three, as we do of three human perſons.

That Chriſt, the Second Perſon, had a being, before he was born of a virgin, is ſo evident from revelation, that we can make no ſenſe or coherence of ſcripture, without allowing it; and there can be no other purpoſe, in revealing all things concerning him, under the character of a Son, and only-begotten Son, but to convince us, that he has all the natural, eſſential attributes of his Father, that, as a human ſon poſſeſſes the entire human nature, ſo the Son of God poſſeſſes the entire Divine Nature.

That the Holy Spirit, who is in ſcripture diſtinguiſhed from the Father and the Son, is a diſtinct Perſon from both, is plain from the commiſſion given the Apoſtles to baptize, in the Name of the Father, and of the Son, and of the Holy Ghoſt. This form, if each of theſe be not a diſtinct Perſon, ſufficiently tends to confound mankind. If the Holy Ghoſt be not a diſtinct Perſon, but only a Power of the Father, then the ſenſe of it runs thus, "Go and baptize in the Name of the Father, and of the Son, and of the Father again." Therefore to ſay, the Third Perſon, here mentioned, is a mere Name, and imports only the Power of the Father, is not only charging God with laying a ſnare to deceive us, but denying his commiſſion to be common-ſenſe.

That the Holy Spirit is God, is evident from revelation, which every where diſtinguiſhes him by this peculiar character Holy. For abſolute holineſs is the peculiar attribute of the abſolutely ſupreme God; and He being every where called "The Holy Spirit," by way of excellency, and diſtinction from all created ſpirits, that epithet muſt imply an original, intrinſic, and eſſential holineſs in Him. Eſpecially if we obſerve, that this is his conſtant, diſtinguiſhing character,

ter, not only where he is mentioned with relation to us, but alſo where he is named, together with the Father and the Son. Inſomuch that He alone is expreſsly ſtiled Holy, wherever the Three Perſons are expreſsly named together in ſcripture.

The word Holy in thoſe places cannot be added, in oppoſition to the Father and the Son; nor as excluſive of them; becauſe they are both abſolutely holy, as well as the Spirit; ſo that they naturally lead us into a belief, that his is the ſame holineſs with that of the Father and the Son, namely, the intrinſic holineſs of Jehovah, the Moſt High, the Supreme God. To this if we add, that He is called, "The Spirit of holineſs, the Spirit of glory, the Eternal Spirit," and very often, the Spirit of God; as particularly at the baptiſm of Chriſt, where he was perſonally diſtinguiſhed from the Father, even in a viſible appearance. We muſt have our reaſon ſtrangely amuſed by ſubtlety and criticiſm, and be turned quite out of the plain way of thinking, before we can underſtand theſe revelations to mean any thing elſe, than that he is God, equal with the Father.

The ſum is this. Since both reaſon and revelation ſhew, there is but one God, we can own and worſhip but one. And ſince that one God is ſet forth to us in Scripture, under three diſtinct relations, and accordingly repreſented by diſtinct perſonal names, and characters, and operations and offices: therefore we worſhip but one God, with this diſtinction of his own making, not ours.

It is ſaid, "Thou ſhalt worſhip the Lord thy God, and Him only ſhalt thou ſerve:" by which all Divine worſhip is utterly cut off from the Son and Holy Ghoſt, unleſs they are one with the Lord our God. Again, it is written, The Lord thy God is one Lord, whom we are to love with all our heart, mind, ſoul, and ſtrength. But if ſo, all Divine love is cut off from the Son and Holy Ghoſt, unleſs they are that one Lord our God, who is a jealous God, and will by no means ſuffer any part of his worſhip to be paid to any other.

According to this plain and natural way of thinking,

as

as we are baptized by one and the ſame ſolemn act of worſhip, "In the name of the Father, and of the Son, and of the Holy Ghoſt:" ſo we ever after adore them, without any degrees or inequality of worſhip; which, indeed, as it is truly Divine, can admit of no degrees or inequality. Whereas they, who argue for an inequality in the Divine Perſons, and for an inferiority of nature in the Son and Holy Ghoſt to the Father, neceſſarily involve themſelves and all their adherents in endleſs uncertainty and confuſion. For they can never ſettle the different kinds and degrees of that lower Divine worſhip, (a contradiction in the very terms) which is to be paid to the Son and the Holy Ghoſt. They can never diſtinguiſh it with ſuch exactneſs, that it ſhall neither be the worſhip due to the Supreme God, that honour, which is to be paid to mere creatures, and varied according to their ſeveral dignities.

But to make it yet more clear, that the mind of man cannot, without abſurdity, have any other conception of the Son and Holy Ghoſt, than as being one abſolutely Supreme God with the Father, and one joint Object of all Chriſtian worſhip; let us collect the two ſeemingly-inconſiſtent doctrines, into oppoſite propoſitions.

There is no other God, but one.

Thou ſhalt worſhip the Lord thy God, and Him only ſhalt thou ſerve.

On this ſide, the precepts are expreſs and poſitive, for our believing in one God alone, and for paying Divine worſhip to Him only. They are full and peremptory, againſt addreſſing ourſelves religiouſly to any other, than that one Supreme God, who is a jealous God, and will

Let all the Angels of God worſhip Him.

Baptize all nations in the name of the Father, and of the Son, and of the Holy Ghoſt.

On this ſide, the precepts are equally expreſs and poſitive, for our believing the Son and the Holy Ghoſt to be God, and for the whole intelligent creation to pay Divine worſhip to the Son in particular. They are likewiſe full and and peremptory for our addreſſing

our

will not ſuffer any degree of Divine worſhip to be directed to any other. Nor can we frame any other notion of idolatry, than the addreſſing ourſelves either in body or mind, by way of religious worſhip to any other being, than to the Supreme God.

ourſelves in one of the moſt ſolemn acts of Divine worſhip, jointly to the Father, Son, and Holy Ghoſt. And as we are initiated into Chriſtianity by this act, ſo we are ever after bleſſed in the name of the three jointly: and all this, without the leaſt direct or indirect mention, or intimation, of any inequality in their natures, or of any diſtinction in their worſhip.

Now both theſe precepts are expreſs Scripture, and therefore equally objects of our faith; it being evident, that here is no contradiction in terms, and that the ſeeming contradiction is with regard to a unity and diſtinction, for the direct apprehenſion of which there is no capacity in the mind of man. The wiſdom of God has left it for us to believe them both, and to reconcile them according to the beſt of our underſtanding: not by taking upon us to ſhew, how the Divine Nature is One, and how it is Three; but by ſolving the ſeeming oppoſition, in a way moſt obvious to a plain capacity; that is, by concluding, ſince there is but one God, who alone is to be worſhipped, and ſince the Son and Holy Ghoſt are both called God in Scripture, and expreſsly commanded to be worſhipped; therefore they are One with the Moſt High God, though how they are One, we cannot comprehend.

Thus has the Goſpel-revelation improved the knowledge of mankind, in theſe important points. And it has no leſs improved our knowledge, in the grand article of future rewards and puniſhments.

As to rewards, 1. Whereas all, that was before expected in the other world, was ſenſual pleaſures for the body, and pleaſing contemplation for the ſoul. Now we learn the joys of heaven to be of a ſort, whereof

whereof nature can give us no conception: we ſhall be as the angels of God in heaven.

2. The reſurrection of the ſame body, is a point entirely new, of which Chriſt's riſing with the ſame body aſſures us. That this body will be changed, is likewiſe entirely new; that this change ſhall be effected in a moment; that the dead in Chriſt ſhall riſe firſt; that their change ſhall be into the likeneſs of Chriſt's glorious body: all which particulars are beyond whatever could have been ſuggeſted, by the mere underſtanding of man.

Another inſtance of Revelation, entirely new with reſpect to theſe rewards, is, that of living for ever in the immediate preſence of God, the fountain of all happineſs. We are now informed, that we ſhall ſee God, as He is, face to face, in whoſe preſence is fulneſs of joy; that we ſhall be where he is, ſhall behold his glory, and ſhall ſhine forth as the ſun in the kingdom of our Father. This is a ſtrain, no imagination, merely human, could ever reach or aſpire to. We may add, that whatever the wiſeſt heathens ſpoke of future rewards, was only from faint conjecture: whereas now we have the plain, and expreſs, and repeated promiſe of God for them.

As to future puniſhments, we learn from Revelation alone,

1. That they are both for ſoul and body, which are diſtinguiſhed by the worm that dieth not, and the fire that is not quenched. And accordingly we are bid to fear Him, who is able to deſtroy both body and ſoul in hell.

2. That the ſoul will be puniſhed with everlaſting deſtruction, from the preſence of the Lord. That the chief of all miſery, in another life, would be, excluſion from the ſight of God, was never thought of by the wiſeſt heathens, who placed all happineſs in themſelves.

3. That the body will be puniſhed by fire, than which we have not any Revelation more expreſs and poſitive. And as it is an inſtance of the great goodneſs of God, that the joys of heaven are repreſented, figuratively, as exceeding the utmoſt of our conceptions;

tions; ſo it is an argument of his ſtrict juſtice, that the pains of hell are more literally foretold.

4. The eternity of theſe puniſhments is revealed, as plainly as words can expreſs it. Not that the puniſhments denounced are mere arbitrary ſanctions, like thoſe annexed to human laws. But thoſe denunciations are withal ſo many previous warnings of the inevitable conſequence, the natural tendency of ſin to miſery. So that an unrepenting ſinner cannot be otherwiſe than miſerable, in another life, by a neceſſity of nature: ſince there never can be any alteration of his condition, without ſuch a change of the whole man, as would put the natural and ſettled order of the creation out of courſe.

With reſpect to theſe rewards and puniſhments, we have theſe farther revelations: that the very Day is appointed by God, in which He will judge the world in righteouſneſs, by the Man, whom He hath ordained; that He hath committed all judgment to the Son; and that all mankind muſt come upon their trial at once. The glorious pomp and majeſty of his appearance, the awful ſolemnity of the whole procedure, nay, the very words of the ſentence, both on the juſt, and on the unjuſt, are diſcovered to us. It is farther revealed, that in this day of God, while He deſcendeth with ten thouſands of his angels, the heavens being on fire, ſhall be diſſolved, and the elements ſhall melt with fervent heat. Theſe are the terrors of the Lord, which are ſufficient to make the ſtout-hearted tremble, and are ſuch motives to all holineſs of heart, and holineſs of converſation, as nothing but infidelity, or wilful want of conſideration, can render ineffectual.

HAVING now, as my leiſure and abilities permitted, taken a Survey of the Wiſdom of God in the Creation; before I conclude, it may not be improper to add ſomething, in anſwer to thoſe on the one hand, who imagine all inquiries of this kind to be vain, fruitleſs labour; and thoſe on the other, who ſpend more

time therein, than is conſiſtent either with religion or reaſon.

I do this chiefly in the words of that great ornament of his profeſſion, the Lord Chief Juſtice Hale. He ſuppoſes the good ſteward giving in his account, at the laſt day, thus to ſpeak. (Happy is he, who can adopt his words, in ſpeaking to the Judge of all!)

1. I have not looked upon thy works inconſiderately, and paſſed them over as ordinary things. But I have ſtudiouſly and diligently ſearched into them, as things of great eminence and wonder; and have eſteemed it part of the duty, which the wiſe God of nature requires of the children of men, who, for that very end, expoſed theſe his works to the view of his intelligent creatures, and gave us not only eyes to behold, but reaſon, in ſome meaſure, to underſtand them. Therefore I have ſtrictly obſerved the frame of the world, and its ſeveral parts, the motion, order, and Divine economy of them. I have ſearched into their quality, cauſes, and operations; and have diſcovered as great, if not greater matter of admiration therein, than in the beauty, which at firſt view, they preſented to my ſenſe.

2. And this obſervation did not reſt in the bare peruſal of the works themſelves, or in the ſearching out, ſo far as that could be done, their immediate natural cauſes. But I traced their being, dependence, and government, unto Thee, the Firſt Cauſe of all. And by this tracing of things to their Original, I was led to a demonſtrative conviction, that there is a God, who is the Great Cauſe, both of their being and motions: yea, that there is but one God; that He is moſt Powerful, moſt Wiſe, knowing all things, governing all things, ſupporting all things. Upon theſe convictions, I was ſtrengthened in the belief of thy holy word, which had ſo great a congruity with theſe truths.

3. And, upon theſe convictions, I did learn the more to honour, reverence, and admire Thee; and to worſhip, ſerve, and obey Thee; to walk humbly, and

ſincerely,

ſincerely, and lawfully, before Thee, as being preſent with me, and beholding me; to love and adore Thee, as the Fountain of all being and good. When I looked upon the glory and uſefulneſs of the ſun, I admired the God that made it, chalked out its motions, placed it in that due diſtance from the earth, for its uſe and conveniency. When I looked upon the ſtars, thoſe huge and wonderful balls of light, placed at that immenſe diſtance from the inferior bodies, and one from another, their multitude and motion; I admired the wiſdom and power of that God, whoſe hand ſpans the heavens, and has fixed every thing in its place. Nay, when I looked upon the poor little herbs, that ariſe out of the earth, and conſidered the ſecret ſpark of life, which is in every one of them, that attracts, increaſeth, groweth, produces ſeed, preſerves them and their kinds; the various virtues that are in them, for the food, medicine, and delight, of the more perfect creatures; my mind was ſweetly carried up, to the adoration and praiſe of that God, whoſe wiſdom, and power, and influence, and government, are ſeen in theſe footſteps of his goodneſs.

So that take all the wiſeſt and ableſt men, the moſt powerful and the moſt knowing, under heaven, they cannot all equal the wiſdom and power, that are ſeen in a blade of graſs. Nay, they cannot ſo much as trace out, or clearly and diſtinctly decypher, the great varieties in the production, growth, and proceſs, of its ſhort, yet wonderful, continuance. Inſomuch that there is ſcarce any thing upon earth, be it ever ſo inconſiderable, but yields me inſcriptions of the power and wiſdom of its Maker written upon it.

4. In the contemplation of thy great works of the heavens, theſe goodly, beautiful, and numerous bodies, ſo full of glory and light, I could not but make that natural reflection, Lord, what is man, that thou art mindful of him, or the ſon of man that thou regardeſt him? It is true, man, conſidered in himſelf, is a creature full of wonder; but compared with theſe goodly creatures, he ſeems but an inconſiderable thing. I learned hereby, to be humbled to the duſt, and to

adore thy condeſcenſion, that thou art pleaſed from heaven, the dwelling-place of thy Majeſty, to take care of ſuch a worm as man, ſinful man!

5. In the contemplating thy power and wiſdom, in creating and governing the world, I have learned ſubmiſſion to thy will, as being the will of that moſt wiſe God, that by his wiſdom not only created at firſt, but ſtill governs, all things. I have learned to depend upon thy Providence, who, though I am but a worm in compariſon of thy heavenly works, yet am an excellent creature in compariſon of the ravens, and the herbs of the field. Yet thoſe he feeds, and theſe he clothes: and ſhall he not much more clothe and feed me? Thus, I have, in ſome meaſure, improved the talent of thy works, to trace out thy Majeſty, and my own duty.

Now is it vain or fruitleſs labour, thus to ſurvey the wonderful works of God? And yet it is certain, we may run to exceſs, even in inquiries of this nature. We may ſpend far more time and pains therein, than is conſiſtent either with religion or reaſon. Have we not a curious inſtance of this in the writings of a late eminent philoſopher; at the ſame time, a divine by profeſſion, and rector of a conſiderable pariſh, "During the whole time," ſays he, "that I have reſided here, I have not been able, by all my induſtry, to diſcover any more than fifty-three ſpecies [of butterflies!] in this neighbourhood. But I very believe, if God ſpares my life a few years longer, I ſhall be able to find ſeveral more!" Was it not pity, but his life ſhould have been ſpared fifty years for ſo excellent a purpoſe?

To thoſe, who lean on this extreme, I would recommend a few more reflections, extracted from the ſame maſterly writer.

1. My learning of natural cauſes and effects, and of arts and ſciences, I have not eſteemed to be the chief, or the beſt furniture of my mind; but have accounted them droſs in compariſon of the knowledge of Thee, and

thy Chriſt, and him crucified. In acquiring them, I have always taken care, 1. That I might not too prodigally beſtow my time upon them, to the prejudice of that time and pains, which were moſt profitably beſtowed, on the acquiring of more excellent knowledge, and the greater concernments of my everlaſting happineſs.

2. I carried along with me, in all my ſtudies of this kind, the great deſign of improving them, and the knowledge acquired by them, to the honour of thy name, and the greater diſcovery of thy wiſdom, power, and truth; and ſo tranſlated my ſecular learning, into an improvement of Divine knowledge. And had I not ever preſerved that deſign, in my acquirement of natural knowledge, I ſhould have accounted all the time miſpent, which had been employed therein. For I ever thought it unworthy of a man, who had an everlaſting ſoul, to furniſh it with ſuch learning, as either would die with the body, and ſo become unuſeful for his everlaſting ſtate, or that, in the next moment after death, would be attained without labour.

3. My knowledge did not heighten my opinion of myſelf: for the more I knew, the more I knew my own ignorance. I was more and more convinced, that I was very ignorant, even in what I thought I knew. And I found an infinite latitude of things, which I did not know at all. Yea, the farther I waded into knowledge, the deeper ſtill I found it. And it was with me, juſt as it was with a child, that thinks, if he could but come to ſuch a field, or climb to the top of ſuch a hill, he ſhould be able to touch the ſky. But no ſooner is he come thither, than he finds it as far off, as it was before. Juſt ſo, while my mind was purſuing knowledge, I found the object ſtill as far before me as it was, if not much farther; and could no more attain the full and exact knowledge of any one ſubject, than the hinder wheel of a chariot can overtake the former. Though I knew much, that others were ignorant of, yet ſtill I found there was much more, whereof I was ignorant, than what I knew, even in the compaſs of

the

the moſt inconſiderable ſubject. And as my very knowledge taught me humility, in the ſenſe of my own ignorance, ſo it taught me the narrowneſs of my underſtanding which could take in things only by little and little. It taught me, that thy wiſdom was unſearchable, and paſt finding out: yea, and that thy works, though they are but finite in themſelves, and neceſſarily ſhort of the infinite Wiſdom that contrived them, are yet ſo wonderful, as fully to confirm the obſervation of the wiſe man, No man can find out the work, that Thou makeſt, from the beginning to the end. If a man were to ſpend his whole life, in the ſtudy of a poor fly, he will ſtill leave much more undiſcovered, than the moſt ſingular wit ever attained.

4. It taught me alſo, with the wiſe man, (when I looked back on what I had attained) to write vanity and vexation, upon all my ſecular knowledge and learning. That little I knew, was not attained without much labour, nor yet free from much uncertainty. And the great remainder, which I knew not, rendered that I knew, poor and inconſiderable.

5. Hence I did moſt evidently conclude, that the perfection of my underſtanding was not to be found; as neither my happineſs, in this kind of knowledge; in a knowledge thus ſenſibly mixed with ignorance, in the things I ſeemed to know, mingled with pain and diſſatisfaction, in reſpect of the things I knew not. And the more I knew, the more impatient my mind was, to know what it knew not. My knowledge did rather enlarge my deſire of knowing than ſatisfy me. The moſt intemperate ſenſual appetite, was more capable of being ſatisfied by what it enjoyed, than my intellectual appetite was, of being ſatisfied with the things I knew. The enlarging my underſtanding with knowledge, did but enlarge the deſire I had to know. So that the anſwer which was returned to Job, upon his inquiſition after wiſdom, "The depth ſaith, it is not in me; and the ſea ſaith, it is not in me." The ſame account, all my ſeveral kinds of knowledge gave, when I inquired for ſatisfaction in them. My metaphyſics,

ſics, when I had peruſed great volumes of it, was ſo mercurial, I could hardly hold it; and yet ſo endleſs, that the more I read, or thought of it, the more I might. Natural Philoſophy, almoſt in every branch was full of uncertainty. Much of it was grounded on ſuppoſitions impoſſible to be experimented. The latter philoſophers cenſured the former, and departed from them. The lateſt deſpiſed and rejected both, as equally ignorant. The ſubject to be treated of, was as vaſt, as the viſible or tangible univerſe. And yet every individual thing was ſo complicated, that if all the reſt were omitted, this alone had more lines concentered in it, than any one age could ſift to the bottom. Yet any one loſt, or not exactly ſcanned, left all the reſt precarious and uncertain. And what could we expect to know, while we know not ourſelves, not even our own bodies? Yet none could ever do this: the diſquiſition concerning any one part of the human body, the brain, the eye, the blood, the nerves, utterly perplexed the moſt exact ſcrutators. But ſuppoſe it were otherwiſe: ſuppoſe we could attain a full knowledge of Philoſophy, that we could maſter every branch thereof, yet three unhappineſſes attend it:

Firſt, That moſt parts of it are of little uſe; they are only known, that they may be known. That which is of ordinary uſe, is ſoon attained, and by ordinary capacities: the reſt are little better than laborious trifles, curious impertinencies.

Secondly, That they ſerve only for this life: a ſeparated ſoul, or a ſpiritualized body will not be concerned in them.

But admit they ſhould, yet Thirdly, a greater meaſure of ſuch knowledge will be attained, in one hour after our diſſolution, than the toilſome expenſe of an age in this life would produce. What a deal of pains is taken here, concerning the motion of the ſun or earth: concerning the habitableneſs of the moon, and other primary or ſecondary planets; concerning the nature, the magnitude, and the diſtance of the fixed ſtars: concerning the various influences of the heavenly bodies, in their oppoſitions, conjunctions, aſpects? When once the immortal has taken its flight through

the

the ſtories of the heavens, in one moment all theſe will be known diſtinctly and evidently. All our doubts will be reſolved, and our ſouls filled with light, without any mixture of darkneſs.

Upon all theſe conſiderations I concluded, that my intellectual power, and the exerciſe of it in this life, was given for a certain, uſeful and becoming object, even to know thee, the only true God, and Jeſus Chriſt whom thou haſt ſent.

In many parts of the preceding tract, I have occaſionally touched on the littleneſs of human knowledge. Perhaps a few more obſervations on this important head, may not be unacceptable to the ſerious reader. I propoſe them barely as hints, which may be purſued at large, by men of reflection and leiſure.

To begin (where we ended before) with the things which are at the greateſt diſtance from us. How far does the univerſe extend, and where are the limits of it? Where did the Creator "ſtay his rapid wheels?" Where "fix the golden compaſſes?" Certainly himſelf alone is without bounds, but all his works are finite. Therefore he muſt have ſaid at ſome point of ſpace,

"Be theſe thy bounds;
This be thy juſt circumference, O world!"

But where, who can tell? Only the morning-ſtars who then ſang together, the ſons of God, who then ſhouted for joy. All beyond the region of the fixed ſtars is utterly hid from the children of men.

And what do we know of the fixed ſtars? A great, deal one would imagine: ſince, like the Moſt High we too tell their number, yea, and call them all by their names! Thoſe at leaſt which appear to the naked eye, both in the northern and ſouthern hemiſphere. But what are theſe, in compariſon of thoſe which our glaſſes diſcover, even in an inconſiderable part of the firmament? What are one or two and twenty hundred, to thoſe which we diſcover in the milky way alone?

How

How many are there then in the whole expanſe, in the boundleſs field of ether? But to what end do they ſerve? to illuminate worlds? To impart light and heat to their ſeveral choirs of planets? Or (as the ingenious Mr. Hutchinſon ſuppoſes) to gild the extremities of the ſolar ſphere, which, according to him is the only inhabited part of the univerſe; and to miniſter in ſome unknown way, to the perpetual circulation of light and ſpirit?

For our ſakes only that great man apprehends the comets alſo to run their amazing circuits! But what are comets? Planets not fully formed? Or planets deſtroyed by a conflagration? Or bodies of an wholly different nature, of which therefore we can form no idea? How eaſy is it to form a thouſand conjectures: how hard to determine any thing concerning them? Can their huge revolutions be even tolerably accounted for, by the principles of gravitation and projection? Has not Dr. Rogers overturned the very foundation of this faſhionable hypotheſis? What then brings them back, when they have travelled ſo immenſely far beyond the ſphere of the ſolar attraction? And what whirls them on, when by the laws of gravitation, they would immediately drop into the ſolar fire?

What is the ſun itſelf? It is undoubtedly the moſt glorious of all the inanimate creatures. And its uſe we know. God made it to rule the day. It is

"Of this great world both eye and ſoul."

But who knows of what ſubſtance, it is compoſed? Or even whether it be fluid or ſolid? What are thoſe ſpots on his ſurface, that are continually changing? What are thoſe that always appear in the ſame place? What is its real magnitude? Which ſhall we embrace, amidſt the immenſe variety of opinions? Mr. Whiſton indeed ſays, that eminent aſtronomers are nearly agreed upon this head. But they cannot agree concerning his magnitude, till they agree concerning his diſtance. And how far are they from this? The generality of them believe, that he is near a hun-

dred millions of miles from the earth. Others ſuppoſe it to be twenty, ſome twelve millions: and laſt comes Dr. Rogers, and brings a clear and full demonſtration, ſo he terms it, that they are not three millions from each other. What an unbounded field for conjecture is here? But what foundation for real knowledge?

Juſt as much do we know of the feebly ſhining bodies that move regularly round the ſun: of jupiter, ſaturn, and other planets. Their revolutions we are acquainted with. But who is able to this day, regularly to demonſtrate, either their magnitude or their diſtance? Unleſs he will prove, as is the uſual way, the magnitude from the diſtance, and the diſtance from the magnitude; and what are jupiter's belts? Can any man tell? What is ſaturn's ring? The honeſt ploughman knows as well as the deepeſt philoſopher. How many ſatellites, ſecondary planets, move round Jupiter or Saturn? Are we ſure even of their number? How much leſs of their nature, ſize, motions, or diſtances from the primary? But what wonder we are ſo ignorant concerning ſaturn's moons, when we know ſo little of our own? For although ſome men of genius have not only diſcovered

"Rivers and mountains on her ſpotty globe,"

but have travelled over the whole hemiſphere which is obverted to us, (and why is the ſame hemiſphere always obverted? What reaſon can be aſſigned, why we do not ſee the other hemiſphere in its turn?) have marked out all her ſeas and continents, with the utmoſt exactneſs: yea, and carried ſelenography to ſo great perfection, as to give us a complete map of the moon: yet do others (and not without reaſon doubt, Whether ſhe has any atmoſphere, And if ſhe has not any, ſhe can have no rain or dews, nor conſequently either ſeas or rivers. So that after all, we have nothing more than mere conjectures, concerning the neareſt of all the heavenly bodies.

What is it that contains them all in their orbits? And what is the principle of their motions? By what

created

created Power, what outward or inward force are they thrown forward to ſuch a point, and then brought back again to a determinate diſtance from the central fire? Dr. Rogers has evidently demonſtrated, that no conjunction of the centrifugal and centripetal force, can poſſibly account for this, or ever cauſe any body to move in an ellipſis. Will light moving outward, and returning inward in the form of ſpirit, account for them? Nay, if they take away ſome, they plunge us into other difficulties, no leſs conſiderable. So that there is reaſon to fear, that even the Newtonian, yea, and Hutchinſonian ſyſtem, however plauſible and ingenious, and whatever advantage they may have in ſeveral particulars, are yet no more capable of ſolid convincing proof, than the Ptolemaic or Carteſian.

But let us come to things that are nearer home, and ſee what knowledge we have of them. And how much do we know of that wonderful body, that enables me to ſee and know all things around us? I mean light. How is it communicated to us? Does it flow in a lucid river, in a countinued ſtream from the orb of the ſun to the earth? Or does the ſun impel thoſe particles only, which are contiguous to his orb, which impel others, ſo on and on, to the extremity of his ſyſtem? Again, are the particles of light, naturally and eſſentially lucid? Or only by accident, when they are collected! Or when put into motion? Yet again, does light gravitate or not? Does it attract other bodies, or repel them? Is it the ſtrongeſt, or the only repellent in nature, and what communicates that power to all repellents in nature? Is this power the ſame with electricity, or wherein does it differ therefrom? Is light ſubject to the general laws, which obtain in all other matter? Or is it a body ſui generis, altogether different from all other bodies? Is it the ſame, or how does it differ from ether? Sir Iſaac Newton's ſubtle matter? What is ether? Wherein does it differ from the electric fluid? Who can explain (and demonſtrate the truth of his explanation) the phenomena of electricity? Why do ſome ſubſtances conduct the electric matter, and others arreſt its courſe? Why does a

globe

globe of glaſs and another of ſulphur juſt counter-act each other? Why is the coated phial capable of being charged juſt to ſuch a point, and no farther? O Crux Philoſophorum! Superabundant proof of the ſhortneſs of human knowledge!

But let us conſider what is not of ſo ſubtle a nature, nor therefore ſo liable to elude our inquires. Surely we underſtand the air we breathe, and which encompaſſes us on every ſide. By its elaſticity it ſeems to be the grand mover and general ſpring of all ſublunary nature. But is elaſticity eſſential to air, and conſequently inſeparable from it? Not ſo. It has been lately proved, by numberleſs experiments, that it may be fixed, diveſted of its elaſticity, and generated or reſtored to it anew. Therefore elaſticity is not eſſential to air, any more than fluidity is to water. Is it then elaſtic any otherwiſe than as it is joined to another body? As every particle of air, is in its ordinary ſtate, attached to a particle of ether or electric fire, does it not derive its whole elaſticity from this, (perhaps the only true, eſſential elaſtic in nature) and conſequently, when ſeparated from this, loſe all its elaſtic force? For want of which it is then effete, and will neither ſuſtain flame, nor the life of animals.

By what powers do the dew, the rain, the other vapours riſe and fall in the air? Can we account for all the phenomena of them, upon the common principles? And can we demonſtrate that this is the true, the moſt rational way of accounting for them? Or ſhall we ſay, with a late ingenious writer, that thoſe principles are utterly inſufficient? And that they cannot be accounted for at all, but upon the principles of electricity?

Do we thoroughly underſtand the nature and properties of the atmoſphere that furrounds us? That immenſe congeries, not only of air and vapours, whether of a watry or inflammable nature, but likewiſe of effluvia of every kind, which are continually ſteaming out from ſolid as well as fluid bodies, in all parts of the terraqueous globe? Do all our inſtruments, with all

all the improvements of them, ſuffice to give us a thorough knowledge of its conſtituent parts? Do they inform us of their innumerable combinations and changes, with the remote and immediate cauſes of them? Very far from it; and yet it is not a barely curious knowledge, but uſeful in the higheſt degree: ſeeing for want of it, not only various diſeaſes, but often death itſelf enſues.

Let us deſcend to what is of a ſtill more firm and ſtable nature, and ſubject to the ſcrutiny of all our ſenſes: namely the earth we tread upon, and which God hath peculiarly given to the children of men. Do the children of men underſtand this? Of what parts then is it compoſed? I ſpeak now of its internal parts, in compariſon of which the ſurface is next to nothing. Many arguments induce us to believe that the earth is between ſeven and eight thouſand miles in diameter. How much of this do we know? Perhaps ſome cavities, natural or artificial, which have been examined by men, deſcend one, or even two miles beneath its ſurface. But what lies beneath theſe? Beneath the region of foſſils, of ſtones, metals and minerals? Theſe being only a thin exterior cruſt. Whereof conſiſt the inner parts of the globe? Of a Nucleus, (as an eminent man ſuppoſes, in order to account for the variation of the needle) and a luminous medium interpoſed, between that and the outer ſhell? Or is there a central fire, a grand reſervoir, which ſupplies all the burning mountains: as well as miniſters to the ripening of gems and metals, if not of vegetables alſo? Or is the great deep ſtill contained in the bowels of the earth, a central abyſs of waters? Who hath ſeen? Who can tell? Who can give any ſolid ſatisfaction to a rational inquirer?

But what wonder if we are ignorant of its internal nature? For how many parts are there on the ſurface of the globe, which after all the diſcoveries of later ages, are ſtill utterly unknown to us? How very little do we know of the polar regions, either in Europe or Aſia? In Aſia particularly, where all but the ſea-coaſt, is mere terra incognita? How little do we know of the

inland

inland parts either of Africa or America? Either of the ſoil, the climate, the fruits, the animals, or the human inhabitants. So far are we from having any proper knowledge of theſe, that we can ſcarce form any rational conjecture about them.

And who knows what is contained in the broad ſea, in the abyſs that covers ſo large a part of the globe? Many indeed go down to the ſea in ſhips, and occupy their buſineſs in the great waters. But what know they, of what is contained therein: either of its animal inhabitants, its productions of the vegetable kind, or thoſe of a mineral or metallic nature? Moſt of its chambers are inacceſſible to man, ſo that how they are furniſhed, we know not. Leviathan may take his paſtime therein: but they are not deſigned for the children of men.

But let us come nearer home. How little do we know even of the furniture of the dry land? Survey thoſe things which fall directly under our notice, even the moſt ſimple ſtones, metals, minerals. How exceeding imperfectly are we acquainted, with their nature and properties? What is there in the inward conſtitution of metals, which diſtinguiſhes them from all other foſſils? From ſtones in particular? "Why they are heavier." True; but what makes them heavier? I doubt whether Solomon himſelf was able to aſſign the reaſon. What is the original, internal difference between gold and ſilver, or between tin and lead? 'Tis all myſtery to the ſons of men. And yet vain man would be wiſe!

"If all the men in the world, ſays the great Mr. Boyle, were to ſpend their whole lives in the ſearch, they would not be able to find out all the properties of that ſingle mineral, antimony." And if all men could know ſo little of one thing, how little can one know of all?

Let us proceed to the higher parts of the creature. Obſerve the vegetable kingdom. And here alſo whatever

ever diſplays the wiſdom of the Creator, diſcovers the ignorance of his creature. Who can clearly determine even the fundamental queſtion, concerning the general nature of vegetables. Does the ſap perform a regular circulation through their veſſels or not? How plauſible arguments have been brought, both on the one ſide and the other? Who knows the ſeveral ſpecies of vegetables, from the cedar of Lebanon to the hyſſop on the wall? Or rather, (if we would deſcend from the higheſt to the loweſt) to the innumerable grove of plants which appear in the form of mouldineſs; or thoſe more innumerable (if the expreſſion may be allowed) which do not appear to the naked eye at all? Who is able to diſcover the proper ſpecific difference, between any one kind of plant and another? Or the peculiar internal conformation and diſpoſition or their component particles? Yea, what man upon earth thoroughly underſtands the nature and properties of any one plant under heaven?

Aſcend we higher ſtill from plants to animals. But here we are ſtopped in the mid-way. Under which of theſe ſhall we place the innumerable tribes of microſcopic animals, ſo called? Are they real animals in the common ſenſe of the word? Or are they animals, in quite another ſenſe? Eſſentially different from all other ſpecies of animals in the univerſe: as neither requiring any food to ſuſtain them, nor generating or being generated? Are they no animals at all, according to the ſuppoſition of a late ingenious writer,) but merely inanimate particles of matter, in a ſtate of fermentation? So much may be ſaid for each of theſe opinions, that it is not eaſy to fix upon any of them.

If they are animals of a peculiar kind, which neither generate, nor are generated, they ſpread a veil over one conſiderable branch of human ignorance. For how totally ignorant are the moſt ſagacious of men, touching the whole affair of generation? I do not ſay of the generation of inſects and fiſhes: the countleſs fry.

"That by unnumber'd millions multiply."

But

But let us come to that of the moſt perfect animals, yea, of man himſelf. In the book of the Creator indeed, were all our members written; which day by day were faſhioned, when as yet there were none of them. But by what rule were they faſhioned? In what manner? By what degrees from the moment of impregnation? Who can explain.

"How the dim ſpeck of entity began,
To extend its recent form, and ſwell to man?"

By what means was the firſt motion communicated to the punctum ſaliens? When and how was the immortal ſpirit added to the maſs of ſenſeleſs clay? There is no need of deſcending to particulars: for 'tis myſtery all! And after all our reſearches, we can only ſay, I am fearfully and wonderfully made!

But is there any ſuch thing as equivocal generation, whether of plants or animals? It is impoſſible any thing can appear more abſurd to the eye of reaſon? Was there ever an inſtance, ſince the world began, that a houſe grew of itſelf? Nay, ſo much as a bed, a table, a chair, or the ſmalleſt piece of houſehold furniture? And yet how trifling and inartificial is the conſtruction of theſe to that of the meaneſt plant or animal? What is the workmanſhip of Whitehall or Weſtminſter-abbey, to that of a tree or a fly? And yet on the other hand, if we deny ſpontaneous generation, what difficulties ſurround us? If we can give a plauſible account of the propagation of miſſeto on trees, and a few of the plants growing on the tops of houſes, or on the walls of churches and towers, yet how many more confound all our ſagacity? And how many animals are diſcovered in ſuch places as no animal of that kind ever frequented?

With regard to the loweſt claſs of animals, inſects, almoſt innumerable are the diſcoveries which have been made within few years particularly by the ingenious and indefatigable Mr. Reaumur: but how inconſiderable is all this, in compariſon of that which

ſtill remains undiſcovered? How many ſpecies, how many entire genera of theſe, are we totally acquainted with? How many millions by their extreme minuteneſs elude our moſt careful inquiries? And the minuter parts of larger animals, eſcape our utmoſt diligence? So that all we can attain to is an imperfect knowledge of what is obvious in their compoſition.

Have we a more perfect knowledge of fiſhes than of inſects? How many of the inhabitants of the waters, are entirely concealed from human view, by the element wherein they live? It is not permitted to the ſons of men, to walk through the paths of the ſea, nor conſequently to trace out their ſeveral kinds or ſpecies with any exactneſs. But it is highly probable theſe are far more numerous, than the ſpecies of land-animals: as the diſtance between the ſmalleſt and the largeſt of ſea-animals, is ſo immenſely greater; from the Minow, for inſtance, (though this is far from being the leaſt) to the Norwegian whale: to ſay nothing of Biſhop Pontoppidan's Craken and Sea-ſerpent, which I doubt never exiſted but in his own imagination. And with regard to the ſpecies we are acquainted with, how little is it that we know? Only a few of their general properties: enough to ſatisfy our need, but not our curioſity.

We are ſomething better acquainted with the inhabitants of the air; Birds being more acceſſible to us; yet upon the whole, we are very far from being perfectly acquainted with them. Of many we know little more than the outward ſhape. We know a few of the obvious properties of others, but the inward, ſpecific difference of very few. And we have a thorough adequate knowledge of none.

"However we have a more extenſive knowledge of beaſts, many of which are our domeſtic companions." Certainly we have. And yet a thouſand queſtions may be aſked even concerning theſe, which we are in nowiſe able to anſwer. To touch only on two or three general heads. Do they reaſon, or do they not? Whence

Whence ariſe the different qualities and tempers, not only in different kinds and ſpecies; but even in the individuals of one ſpecies, as in dogs, cats, and horſes? Are they mere machines? If we aſſert they are, it inevitably follows, that they neither ſee, nor hear, nor ſmell, nor feel. For of this mere machines are utterly incapable. Much leſs can they know or remember any thing, or move any otherwiſe than they are impelled. But all this, as numberleſs experiments ſhew, is quite contrary to matter of fact. On the other hand if they are not mere machines, if they have either ſenſation, or knowledge, or memory, or a principle of ſelf-motion, then they are not mere matter; they have in them an immaterial principle. But of what kind? Will it die with the body, or not? Is it mortal or immortal? Here again we are got into an unknown path. We cannot order our ſpeech by reaſon of darkneſs.

But although we know ſo little either of the things that are above us, of thoſe that are beneath us, or of thoſe that ſurround us on every ſide, yet it is to be hoped, we know ourſelves: and of all, this is the moſt uſeful, the moſt neceſſary knowledge. But do we truly know ourſelves? Do we know the moſt excellent part of ourſelves, our own ſoul? That it is a ſpirit, we know. But what is a ſpirit? Here again we are at a full ſtop. And where is the ſoul lodged? In the pineal gland? The whole brain? In the heart? The blood? In any ſingle part of the body? Or, is it (if any one can underſtand thoſe terms.) All in all, and all in every part. How is it united to the body? What is the ſecret chain, what the bands that couple them together? Can the wiſeſt of men give a ſatisfactory anſwer, even to theſe few plain queſtions?

As to the body, we glory in having attained abundantly more knowledge than the ancients. By our glaſſes we have diſcovered very many things, which we ſuppoſe they were wholly unacquainted with. But have we diſcovered, why we perſpire three parts in four leſs, when we ſweat than when we do not? What a total miſtake is it then to ſuppoſe ſweat is only an increaſe

creaſe of inſenſible perſpiration! Have we diſcovered, why one part of mankind have black ſkins, and the other white? It is not owing to the climate: for both black men and white are born in the ſame latitude. And have not negroes the ſame fleſh and blood with us? But what is fleſh? That of the muſcles in particular? Are the fibres out of which it is woven, of a determinate ſize? So that when you have divided them into ſmaller and ſmaller, to a certain point, you come to thoſe of the ſmalleſt kind? Or are they reſolvible (at leaſt in their own nature) into ſmaller and ſmaller in infinitum? How does a muſcle act? If you ſay by being inflated, and conſequently ſhortened: I aſk again, but what is it inflated with? If with blood, how and whence comes that blood? And what becomes of that blood, whither does it go, the moment the muſcle is relaxed? What is blood? Of how many ſorts of particles does it eſſentially conſiſt? Of red globules and ſerum? But in the famous inſtance, the man bled at the noſe, till what was diſcharged had no redneſs left. By what force is the circulation of the blood performed? Can any one ſuppoſe the force of the heart, is ſufficient to overcome the reſiſtance of all the arteries? Are the nerves pervious or ſolid? How do they act? By vibration or tranſmiſſion of the animal ſpirits? What are the animal ſpirits? If they have any being, are they of the nature of blood or ether? What is ſleep? Wherein does it conſiſt? We do not inquire, What are the effects of it (Ceſſation of voluntary motion and ſo on) but what is the thing itſelf, the cauſe of theſe effects?) What is dreaming? By what criterion can we diſtinguiſh dreams from waking thoughts? I mean, by what means may a dreaming perſon then know that he is in a dream? What is (the Conſanguineus Somni) death? When do we die? You ſay. "When the ſoul leaves the body." This cannot be denied. But my queſtion is, When does the ſoul leave the body? When we ceaſe to breathe, according to the maxim, Nullus Spiritus, nulla vita? This will not hold; for many have revived after reſpiration was utterly ceaſed. When the circulation of the blood ſtops? Nay, neither will this hold; for many have recovered after the pulſe

was

was quite gone. When the vital warmth ceaſes, and the juices loſe their fluidity? Even this is not a certain mark. For ſome have revived after the body was quite cold and ſtiff: a caſe not uncommon in Sweden. By what token then can we ſurely know? It ſeems, none ſuch can be found. God knows when the ſpirit returns to him. And the ſpirit itſelf: but none that dwells in a body.

What cauſe have we then to adore the wiſdom of God, who has ſo exactly proportioned our knowledge to our ſtate? We may know whatever is needful for life or godlineſs, whatever is neceſſary either for our preſent or eternal happineſs. But how little beſide can the moſt penetrating genius know with any certainty? Such pains, ſo to ſpeak, hath God taken to hide pride from man! And to bound his thought within that channel of knowledge, wherein he already finds eternal life.

CONTENTS

CONTENTS

OF THE

FOURTH VOLUME.

CHAP. IX.

Continuation of Animal Economy conſidered in Inſects.

	Page
1. Thoughts on the regeneration of earth-worms	3
2. The regeneration of freſh-water worms -	4
3. Immenſe diſtinctions in the gifts of Nature -	5
4. The metamorphoſes of inſects - -	ib.
5. The metamorphoſes into an oblong ball -	6
6. Of the ſpider-fly - - - -	7
7. Sketch of a diviſion of inſects - -	8
8. The moultings or diſeaſes of inſects - -	9
9. Sketch of a theory of metamorphoſes -	10
10, 11, 12. Reflections on metamorphoſes	10—14

CHAP. X.

Parallel between Plants and Animals.

1. Introduction - - - - -	14
2. The ſeed - - - - -	ib.

3. The

Page

3. The egg - - - - - 1
4. The bud, the fœtus - - - 16
5. The nutrition of the plant, and of the animal ib.
6. The growth of the plant - - - 18
7. The growth of the animal - - - 19
8. The fecundation of the plant - - 21
9. The fecundation of the animal - - ib.
10. The multiplication of the plant, and of the animal - - - - - 22
11. Irregularities in the generation of the plant, and in the generation of animals - - 23
12. Diſeaſes incident to plants and animals - 24
13. Old age and death of the plant and of the animal - - - - - 25
14. Other ſources of analogy between the plant and animal - - - - 26
15. Their place and number - - - 27
16. Fecundity - - - - - 28
17. Appoſition in variety of plants and animals - 29
18. The form and the ſtructure - - - 32
19. The circulation - - - - 36
20. The diſtribution of aliment - - - 38
21. Reflections - - - - - 39
22. Sap circulates in plants as blood in animals - 41
23. The neceſſity of circulation - - - 42
24. The loco-motive faculty - - - ib.
25. The diſtinction between plants and animals - 43
26. The feeling - - - - 44
27. The nutrition - - - - 46
28. Irritability - - - - - 47

CHAP. XI.

Of the Induſtry of Animals.

1. Treating in general of the inſtinct of animals 49
2. Wiſdom diſplayed in the preſervation of the ſpecies - - - - - 51
3. Of animals that ſcarce take any care of their eggs - - - - - 5

4. Of

Page
4. Of the peculiar attachment of other animals to them - - - - - 53
5. Of divers ſpecies of ſolitary flies - - ib.
6. The different degrees of art and ſagacity diſplayed in their work - - - 54
7. That brutes act in concert with each other - 55
8. Reflections - - - - - ib.
9. Birds of paſſage - - - - 57
10. Societies of animals properly and improperly ſo called - - - - ib.
11. Common caterpillars - - - 58
12. Proceſſionary caterpillars - - - ib.
13. Remarkable procedure of caterpillars that live in ſociety - - - - 59
14. Ants - - - - - 60
15. Thoughts on the policy of bees - - 61
16. Of Beavers - - - - - 62
17. Reflections on beavers - - - 63

CHAP. XII.

Continuation of the induſtry of Animals.

1. A ſummary account of the induſtrious proceedings of divers inſects relative to their metamorphoſes - - - - 64
2. Caterpillars that faſten themſelves with a girdle - - - - - 65
3. Caterpillars that form cones - - ib.
4. Of ſpinning caterpillars - - - 66
5. Inſects that live in fruits - - - 67
6. Inſects that fold and roll up leaves - - ib.
7. Inſects that are miners of leaves. - - 69
8. Wonderful properties of thoſe miners 70
9. Falſe moths - - - - 71
10. Of moths in general. Domeſtic moths - 73
11. Field moths - - - - 74
12. Aquatic moths - - - - 75
13. Reflections on the various proceedings of inſects - - - - - ib.
14. Proceedings of ſhell-fiſh. The Tellina - 77

15. The

Page

15. The cutler: its peculiar methods - - 78
16. The dails or pholas - - - 79
17. Divers ſea-inſects or animals. Nettles - 80
18. Theſe nettles feed on ſhell-fiſh - - 82
19. Reſemblance of nettles to polypuſes - 83
20. Stars - - - - - 85
21. Sea hedgehogs - - - - 87
22. Bernard the hermit - - - 88
23. Shell-fiſh that ſpin. Muſcles and Pinnæ Marinæ. - - - - - ib.
24. Shell-fiſh and other animals that faſten themſelves by a ſort of glue or ſtony juice. - 91
The proceedings of fiſhes - - - 92
25. Of the proceedings of birds - - - 95
26. Of the proceedings of quadrupeds. The rabbit - - - - - 96
27. The monkey - - - - 97
28. The caterpillar that conſtructs his cone like a grain of corn - - - - 98
29. Analogous proceedings of other inſects - 99
30. Reflections on the induſtry of animals - 100
31. The tapeſtry-bee - - - - 101
The ſubtleties of the hare and ſtag - - 104
32. The ſkilfulneſs and ſubtlety of the fox - 105
Concluſion - - - - 106
Extract of Mr. Duten's inquiry into the origin of the diſcoveries attributed to the moderns - - - - - 107
The Author's Preface - - - 108

CHAP. I.

Of the circulation of the Blood, and the Fallopian Tubes.

1. Injuſtice done to the ancients, in endeavouring to deprive them of the glory of the moſt important diſcoveries - - 110
2. Scarce any aphoriſm in medicine new ſince the time of Hippocrates - - - ib.
3, 4. The circulation of the blood clearly diſcovered by Hippocrates - - - ib.

5. Plato

Page

5. Plato and Ariſtotle's ſentiments on the circulation of the blood - - - 111
6. Julius Pollux and Apuleius deſcribe this circulation as clearly as any of the moderns ib.
7. The motion of the pulſe owes its origin to the heart - - - - - 112
8. Servetus diſcovered three ſorts of ſpirits in the human body - - - - ib.
9. The valves of the heart diſcovered by Father Paul - - - - - 113
10. Of the fallopian tubes - - - ib.

CHAP. II.

Of the Chirurgery of the Ancients.

1, 2. Extract of Mr. Bernard's thoughts on ancient chirurgery - - - 114
The moderns have contributed to the advancement of chirurgery - - - ib.
3. The grand operation for the ſtone was the invention of Johannes de Romanis - - 116
4. The cure of the Hernia Inteſtinalis exactly deſcribed by the ancients - - ib.
5. The real cauſtic well known by Hippocrates 117
6. All ſorts of amputations ſucceſsfully performed by the ancients - - - 118
7. Reflections on ancient and modern chirurgery ib.

CHAP. III.

Of Generation.

1. Harvey and Redi's ſentiment on generation - 119
2. A different ſentiment thereon ſupported by Lewenhoek - - - - ib.
3. Arguments in ſupport of the firſt ſentiment drawn from the analogy of Nature in the production of plants and animals - 120
4. Empedocles and Ariſtotle's opinions on generation - - - - - ib.

Page

5. Herodotus accounts for numbers of fiſhes being found on land - - - 120
6. Hippocrates deſcribes a fœtus ſix days old - 121
7. How the fœtus is produced - - ib.
8. Macrobius's account of generation - - ib.
9. The ancients amazingly exceed the moderns in their ſentiments on generation - ib.
10, 11. Democritus, and other ancients' opinions on this ſubject - - - - 122
12. Hippocrates aſſerts, that nothing is born but what had a prior exiſtence - - 123
13. Objection urged, and ſolved - - ib.
14. Plato, Seneca, and Tertullian clearly deſcribe the nature of generation - - - 124
15. Diſcovery of the multiplicity of animation which the polypus is capable of - - ib.

CHAP. IV.

Of the Sexual ſyſtem of Plants.

1. The organs whereby the propagation of plants is effected - - - 125
2. Linnæus has reduced all trees and plants to particular claſſes - - - 126
3. The moderns give more accurate accounts of plants than the ancients - - - 127
4, 5. Theophraſtus's opinion on the diſtinction of plants - - - - ib.
6, 7. Various ſentiments of the ancients, as to the difference of ſexes in plants - - ib.
8, 9. Empedocles and Ariſtotle give a clear account of the diſtinction of ſexes in plants - 128
10. Theophraſtus and Pliny's inſtances of the fecundation of plants - - - ib.

CHAP. V.

Of the Chymiſtry of the Ancients.

1. Chymiſtry had its origin in the country of Chemia in Egypt - - - 129

2. Tubal

Page

2. Tubal Cain, and thoſe ancients who wrought in braſs and iron, well underſtood the chymical proceſs - - - - 130
3. By the power of chymiſtry Moſes rendered the golden calf potable - - - ib.
Experiments in chymiſtry, of Frederick the Third, King of Denmark - - 131
4. The mummies kept ſo long in high preſervation, demonſtrate the ſkill of the Egyptians in chymiſtry - - - - ib.
5. The ancients' manner of painting on linen, proceeded from their knowledge of chymiſtry - - - - - 132
6. Their method of imitating precious ſtones - 133
7. Their pharmacy much depended on chymiſtry - - - - - ib.
8. The invention and uſe of the Alembic - 135
9. The ancients knew the various qualities of ſalts - - - - - ib.
10. Cleopatra, by the aid of chymiſtry, diſſolved a pearl of great value in acids - - 136
11. The ancients had a method of rendering glaſs ductile - - - - - 137
12. Democritus, the parent of experimental philoſophy, imitates nature in her production of precious ſtones - - - 139
13. The ancients knew the uſe of gunpowder - ib.
14. Objection urged, and clearly refuted - 141

CHAP. VI.

Of Senſible Qualities.

1. That ſenſible qualities exiſt in the mind - 142
2. Deſcartes and Mallebranche's opinions on this ſubject - - - - - ib.
4. The ancients and moderns agree on this point 144
5, 6, 7. Democritus, Sextus Empiricus, and Protagoras, ſhew, that the exiſtence of external things conſiſt in the impreſſions we perceive in ourſelves - - - 145

Page
8, 9. Ariſtippus's experiments hereon - - 146
10, 11, 12. Plato and Epicurus clearly diſtinguiſh between ſenſible qualities, and the objects which cauſe them - - - 147
13. The moderns have ſcarcely advanced any thing new on this ſubject - - 149

CHAP. VII.

Of Animated Nature.

1, 2. The ancients underſtood the natural hiſtory of animals and minerals better than the moderns - - - - 150
3. That bodies are compoſed of ſimilar and diſſimilar particles - - - - 151
4, 5, 6. Of animal and vegetable nutrition - 152
7. Of the formation of a fœtus - - 154
8. Reflection - - - - ib.

CHAP. VIII.

Nature Active and Animated.

1, 2. That animal and vegetative ſubſtances are originally the ſame - - - 155
3. That there are active principles in the univerſe that produce motion - - - 156
4, 5, 6, 7. The ancients' opinions on this ſubject ib.
8. The ancients' ſentiments reſpecting generation 157

CHAP. IX.

Of Thunder, and Earthquakes; of the virtues of the Magnet; of the ebbing and flowing of the Sea; and of the ſource of Rivers.

1. The introduction - - - - 158
2. The moderns divide in their opinions concerning the cauſe of thunder - - 15
3, 4, 5. The ancients' ſentiments on what occaſions thunder - - - - ib.

Page

6. The moderns' account of the cauſe of earthquakes - - - - - 160
7, 8. Ariſtotle and Seneca's ſentiments on earthquakes - - - - - ib.
9. The moderns aſſert, that the ſun and moon act reciprocally in cauſing the ebbing and flowing of the ſea - - - 161
0. Pliny's account exactly agrees with this - ib.
11. The moderns' account of the wonderful properties of the loadſtone - - - 162
12. The ancients clearly knew the virtues of the loadſtone - - - ib.
13. Modern Naturaliſts are divided in their opinions as to electric matter - - 163
14. That rivers return from the ſea to their ſources by ſubterraneous paſſages - - ib.

CHAP. X.

Of Ether, and of the weight and Elaſticity of the Air.

1. That ether is a fluid more ſubtle than the air 164
2, 3, 4. The ancients deſcribe ether to be a ſubtle, active fire, which diffuſes itſelf through the univerſe - - - 165
5. The nature of air, as well as ether, clearly underſtood by the ancients - 166
6. The general notions reſpecting fire - - 167

CHAP. XI.

Newton's Theory of Colours, indicated by Pythagoras and Plato.

1. That colours reſult from the different modifications of reflected light - - - ib.
2. Diverſity of colours formed by the combined intermixture of others - - - 168
3. That light is the action of a ſubtle matter upon the organs of light - - - 169
4. Experiment reſpecting light - - 170

CHAP. XII.

Of Burning Glaſſes.

		Page
1, 2.	Introduction - - -	171
3, 4.	Deſcription of the glaſs Archimedes made uſe of in ſetting fire to the Roman fleet, at the ſiege of Syracuſe - - -	172
5.	The manner of uſing this glaſs - -	173
6.	A fleet deſtroyed by means of glaſſes at the ſiege of Conſtantinople - - -	i.
7.	Undoubted teſtimonies of the power of the glaſſes - - - - -	174
8.	The ancients were well acquainted with the nature of refracting burning-glaſſes -	175

CHAP. XIII.

Of univerſal gravity, and centripetal and centrifugal force. Laws of the movements of the Planets, according to their diſtance from the common centre.

1.	The moderns have demonſtrated the laws of univerſal gravitation - - -	176
2, 3.	The ancients were not acquainted with theſe laws - - - -	177
4.	Of the ſoul of the world, which puts all nature in motion - - - -	ib.
5, 6.	What retains the heavenly bodies in their orbits - - - - -	ib.
7, 8.	The tendency of all bodies to one common centre - - - - -	178
9.	Various opinions as to the courſes obſerved by the planets - - - -	179
10.	The harmony which reigns in the courſe of the planets - - - -	ib.
11.	Muſical experiment - - -	180
12.	How bodies are conſtantly kept at an equal diſtance from their proper centre -	ib.

CHAP. XIV.

Of the Copernican ſyſtem; the motion of the Earth about the Sun; and the Antipodes.

Page

1. Introduction - - - - 181
2. The ſyſtem of Copernicus deſcribed - - 182
3, 4, 5. The ancients were well acquainted with the movement of the earth round the ſun 183
6. Plato's opinion of the ſun moving round the earth, exploded - - - - ib.
7, 8. That the earth is round, inhabited on all ſides, and of courſe has antipodes - 184
9. Of the ſphericity of the earth - - ib.

CHAP. XV.

Of the revolution of the Planets about their own axis.

1. That every planet has its particular revolutions 185
2, 3. That the earth turns from weſt to eaſt on its own axis, or centre - - - ib.
4. That the moon has no light of its own, but reflects it from the ſun - - - 186
5, 6. Obſervations on the form and ſituation of the moon - - - - ib.
7, 8, 9. That the moon is an earth like ours - 187
10. Reflection - - - - - 188

CHAP. XVI.

The Milky Way; Solar ſyſtems, or a plurality of Worlds.

1. Introduction - - - - 189
2. That what we call the milky way is a vaſt aſſemblage of fixed ſtars - - 190
3. That thoſe ſtars are ſuns like ours, have planets of their own, and form various ſolar ſyſtems - - - - - 191
4—10. The ancients give cogent reaſons for their opinion of a multiplicity of worlds ib.

CHAP.

CHAP. XVI.

Of Comets.

Page
1. The Newtonian account of comets - - 193
2. The Chaldeans look upon comets as planetary bodies - - - - 194
3, 4. Ariſtotle and Stobæus aſſert, that comets are wandering ſtars, which appear to us only in particular parts of their orbits - ib.
5. Seneca clearly diſcuſſes this ſubject - - 195
6. Reflection - - - - - ib.

CHAP. XVIII.

Of the refraction of Light, and Aſtronomical refraction, and of Perſpective.

1, 2. The advantages of the eaſtern nations in the ſtudy of aſtronomy - - - 196
Their invention of the vibrations of the pendulum, dials, &c. - - - ib.
3, 4. The diſcovery of the refraction of light as ancient as the time of Ptolomy - - 197
5. What is the cauſe of Aſtronomic refraction - 198
6. The difference of magnitude in ſtars accounted for - - - - - 199
7. Perſpective clearly underſtood and deſcribed by the ancients - - - - ib
8. Various conjectures as to the image of the ſun, by collecting its rays - - - 201

CHAP. XIX.

Of the diſcoveries of the Ancients in Mathematics, &c.

1. Introduction . - - - 202
2. Thales was the firſt who predicted eclipſes and made various diſcoveries - - ib.
3. Pythagoras was the firſt who gave fundamental precepts reſpecting muſic - - 203

4. Plato

Page
4. Plato firſt introduced the Geometric Analyſis 204
5, 6. Plain and ſpherical trigonometry, as well as Algebra, owe their origin to Hipparchus ib.
7. Method of meaſuring the diſtance of the ſun from the earth - - - - 206
8. The ancients calculated tables of the motion of the ſun and moon, and made catalogues of the fixed Stars - - - ib

CHAP. XX.

Of Archimedes; of the Mechanics and Architecture of the Ancients; and of Microſcopes. Of Sculpture, Painting, and the origin of Muſic.

1, 2, 3. Brief recital of the amazing mechanical diſcoveries of Archimedes - - 207
4. The mechanical powers uſed by the ancients are beyond conception - - - 209
5. Of the pyramids of Egypt, and ruins of Palmyra and Balbec - - - 210
6. Of the immenſe magnitude and grandeur of Babylon - - - - ib.
7. Other cities of amazing extent - - ib
8. The lake Mocris, a ſtriking proof of the ancients vaſt undertakings - - - 211
9. Of the other pyramids of Egypt - - 211
10. Remarkable inſtances of the immenſe hardneſs of the cement of the ancients - 212
The ancients knew the nature of, and uſed glaſs in their houſes and windows - ib.
11. The ancients ſkill in working in miniature - 213
12. They well knew the nature and uſe of microſcopes - - - - - 214
13, 14. The pre-eminence of the ancients in architecture, engraving, ſculpture, medicine, poetry, and hiſtory - - - ib.
15. Striking inſtances of the ancients excelling in painting - - - - 217
16. Of the beautilfu moſaic work of the ancients 218
17. Of the antiquity and dignity of muſic - ib.

Page

18. Effects of music were no way short in the ancients of what they are among the moderns - - - - - 221
19. The harmony of the music of the ancients - 222
20. Striking instances of the utility of music from the scriptures, and various ancient authors 223
21. General observations respecting the merit of the ancients in music - - - 225
The conclusion, shewing the true state of the discoveries, both of the ancients and moderns - - - - - 226

APPENDIX.

On the bounds and extent of the human understanding - - - - 233

CHAP. I.

Sect. 1. Of the ideas of sensation - - ib.
Sect. 2. Of the idea of spirits - - 235
Sect. 3. Of the properties of ideas of sensation - - - 237

CHAP. II.

Sect. 1. Of the pure intellect and its operations 246
Sect. 2. Of the different kinds of knowledge and evidence - - - 249
Sect. 3. Of the improvement of knowledge by revelation - - - 257
General reflections, shewing the peculiar advantages which result from a proper survey of the wisdom of God in the Creation 265

END OF THE FOURTH VOLUME.

A

GENERAL INDEX

OF THE

PRINCIPAL MATTERS

CONTAINED IN THE

FOUR VOLUMES.

A

	Vol.	Page.
Abſtinence, the utility of - -	1	106
Active Principles in the Univerſe that produce motion - - - -	4	156
Affections - - - - -	1	132
Air - - - - - -	3	231
—— accurately diſcovered by the barometer	1	14
Air Bladder - - - - -	1	245
—— its Nature and Properties -	2	332
—— its Weight or Gravity - -	ib.	ib.
—— its Elaſticity - - -	2	333
—— Experiments on - -	2	336
—— Pump - - - -	2	340
—— Farther Experiments on -	ib.	ib.
—— is in all our Fluids - -	2	341
—— is the cementing and diſſolving principle - - - -	2	343
—— increaſes the weight of oil and vitriol	2	346

	Vol.	Page.
Air, capable of immenſe expanſion -	2	346
—— the difference between fixed and common - - - -	2	347
—— the nature of, clearly underſtood by the ancients - - -	4	166
Albatroſs - - - -	1	226
Aloe, its ſingular properties - -	2	132
Aliment, diſtribution of - -	4	38
Alembic, invention and uſe of - -	4	135
Ambergris - - - -	2	137
Amber - - - -	2	204
Amputations, underſtood by the ancients	4	118
Animals, their generation from eggs -	1	12
Animal Flower - - -	1	267
Animals, transformation of - -	2	63
——— viviparous - - -	ib.	ib.
——— oviparous - - -	2	64
——— their number - - -	2	65
——— the different methods of taking their food - - - -	2	66
——— their clothing - -	2	70
——— their ſagacity - - -	2	71
——— their deſtruction and reparation	2	72
——— World, a comparative view of	2	77
——— agreement with plants - -	2	99
——— natural inſtinct of - -	3	171
——— conſidered as mixed beings -	3	212
——— ſcale, the difficulty, &c. -	3	213
——— their appropriation, &c. -	3	232
——— fecundation - - -	4	21
——— old age and death - -	4	25
Ants - - - - -	2	38
—— their neſts - - -	2	39
—— their appearance viewed through a microſcope - - - -	ib.	ib.
—— they ſleep all the winter - -	2	40
—— their architecture - -	2	41
—— their employment - -	2	43
—— the red, green, and black of Africa	2	44
Ant Eater, or Formico-leo - -	2	45
——— his manner of enſnaring his prey - - - -	ib.	ib.

	Vol.	Page.
Ancients, injuſtice done to - -	4	110
——— their Chirurgery - -	4	114
——— exceed the moderns in their ſentiments on Generation - -	4	121
——— qualities of Salts, known by	4	135
——— underſtood the Hiſtory of Animals, &c. - - -	4	150
——— opinions of the active principles of the Univerſe - -	4	156
——— the pre-eminence of, in architecture, engraving, ſculpture, medicine, poetry, and hiſtory - -	4	214
——— their ſkill in painting -	4	217
Aquatic Boat-Worms - -	1	302
Arboreſcent Star-Fiſh - -	1	283
Artery - - - -	1	27
Armadillo - - -	1	173
Arbor Martis - - -	2	180
Ariſtotelic Elements - -	3	136
Archimedes, a recital of his mechanical diſcoveries - - -	4	207
Aſs, its properties and uſes - -	1	165
Aſtronomy of Comets - -	3	86
Atmoſphere, its uſefulneſs - -	3	54
——— its excellence - -	3	58
Attraction, the power of - -	3	89
Aurora Borealis, or Northern Lights	3	43

B

Babylon, its immenſe magnitude and grandeur - - - -	4	210
Bat - - - -	1	230
Bark of Plants - - -	2	83
Balſam Tree - - -	2	127
Beaver, or Caſtor - -	1	159
——— deſcription of the - -	4	62
——— reflections on - -	4	63
Beaſts, the falling off of their horns -	1	183
Bees - - - -	2	47
—— their habitation - -	2	48

	Vol.	Page.
Bees, policy of	4	60
Beings, the chain of	3	188
——— three kinds of compoſition in	3	191
Beetles	2	64
Bernard the Hermit	4	88
Birds, ſome General Remarks on their motions, &c.	1	188
—— their generation	1	206
—— of Paradiſe	1	221
—— of Paſſage	4	57
—— proceedings of	4	95
Blights, the occaſion of	2	22
Blood, its tranſuſion	1	12
——— farther deſcription of	1	74
——— its circulation	1	99
——— its circulation diſcovered by Hippocrates	4	110
——— Plato and Ariſtotle's ſentiments on	4	111
——— deſcribed by Julius Pollux and Apuleius	ib.	ib.
Body, what its natural ſtate means	1	99
—— its preternatural ſtate	1	116
—— its generation	1	135
—— its different ſtructure in men and beaſts	1	143
Bodies, the agreement and diſagreement, as the head and brain	1	145
—— compoſed of ſimilar and diſſimilar particles	4	151
—— how kept at an equal diſtance from their proper centre	4	180
—— the properties of	3	166
Bogs, origin of	2	273
—— ſeveral in Ireland, England, &c.	ib.	ib.
Bologna Bottles, experiments on	2	329
Bollani	1	265
Bones	1	23
Boyle's Remarks on Natural Philoſophy	3	114
Brain	1	38
Braſs, how made	2	179
Brutes, their vegetative and ſenſitive motions	1	151

	Vol.	Page.
Brutes, the ſoul of	1	151
Bud	4	16
Burning Glaſſes	1	14
——— mountains	2	286
——— iſlands	2	300
——— wells	2	321
——— vapours in Wales	2	325
Butterflies	2	28

C

Cacao-Tree	2	124
Calabria, dreadful earthquake at	2	309
Callao, deſtruction of	2	314
Camel	1	157
Cartilage	1	26
Caterpillars	4	56
——— proceſſionary	ib.	ib.
——— farther account of	2	29
Cauſtic, real, &c.	4	117
Cellular Membrane	1	21
Cerebrum	1	37
Cerebellum	ib.	ib.
Cerus, or Prickly Pear	2	133
Cement of the ancients	4	212
Cameleons, ſeveral kinds of	1	266
Chick, its generation	3	255
Chimpanaze	1	175
Chronology, Aſtronomical Obſervations on	3	111
Chymiſtry	1	14
——— the principles of	3	136
——— its origin, proceſs, power, &c.	4	129
——— its experiments, &c.		
Chylification	1	105
Circulation, the organs of	3	248
——— farther account of, &c.	3	265
Cicadula	2	25
Coco-Tree	2	124
Cochineal	2	25
Cod, coming of	1	269
Cold	3	157

	Vol.	Page.
Colours - - - -	3	151
——— reſult from the different modifications of reflected light - - -	4	167
Comets - - - -	3	68, 69, &c.
——— The Newtonian account of -	4	193
Cuntur of Peru - - -	1	215
Copper - - - -	2	174, 179, 192,
Coral - - - - -	2	135
Corallines, a ſpecies of polypi - -	2	55, 60
Cotton tree - - - -	2	127
Couching, an account of - -	1	47
Coya - - - - -	2	13
Crabs, various particulars of, &c. -	1	250, 257
Crane - - - -	1	222
Creatures produce their own kind -	2	154
Creation - - - -	3	179
Crocodile - - - -	1	295
Cutler - - - -	4	78

D

Dails, or Pholas - - -	4	79
Damps - - - -	3	14
Death - - - -	1	121
—— Watch, its beating &c. - -	2	18
Democritus' opinion on generation -	4	122
Dew - - - -	3	5
Dials, invented by the ancients -	4	197
Diſcoveries made by the operations of medicines, microſcopes &c. - -	1	13, 14
Diſcoveries, the true ſtate of, both of the ancients and moderns - - -	4	226
Diſeaſes, variety of, cauſes of &c. &c. -	1	116 119
——— of plants and animals - -	4	24

	Vol.	Page.
Diſtinction of plants and animals -	4	43
Diviſibility - - - -	3	134
Doronicum - - - -	2	132
Down-bird of Iceland - - -	1	230
Dromedary - - - -	1	158
Drone-fly - - - -	2	25
Dryneſs - - - -	3	157
Dumbneſs removed - - -	1	55

E

Eagles, a remarkable couple of -	1	229
Ear, external, internal parts of &c. -	1	49, 50
Earth - - -	1	15
	2	206, 207
—— revolves round its own axis -	4	185
Earthquakes, cauſes of &c. - -	2	306, 314
Earth-worm, reproduction of its parts -	1	301
——— thoughts on the regeneration of	4	3
Eclipſes, firſt predicted by Thales -	4	202
Egg - - - - -	4	15
Egypt, pyramids of - - -	4	210
Electricity, various particulars of -	3	25, 47
Elements, &c. - - -	3	190
Elementary light - - -	3	146
Elephant - - - -	1	152
Ephemeron, that lives but part of a day	2	27
Eſſay on the production, nouriſhment, and operations of plants and animals -	2	154
Ether - - - -	4	164, 165
Experiments - - - -	2	180
——— ſhewing that vapours from the ſea ſupply fountains and rivers -	3	3
Extenſion, of light &c. - -	3	133, 148
Eyes, various particulars of - -	1	41, 49

F

	Vol.	Page.
Fat - - - - -	1	36
Falling ſtars - - - -	3	25
Fallopian tubes - - -	4	113
Feet - - - - -	1	73
Feeling - - - -	4	44
Fecundation of plants and animals -	4	21, 22
Fecundity - - - -	4	28
Fibre - - - -	1	19
Fire-fly - - - -	2	26
Fire, nature and effects of &c. &c. -	2	280, 285
—— farther account of - -	3	229
Firſt cauſe - - - -	3	179
Fiſhes, the number of &c. &c. - -	1	241, 250
—— proceedings of - -	4	93
—— Herodotus's account of their being found on land - - -	4	120
Fixed ſtars - - - -	3	68, 93
Flea - - - - -	2	15
Fleſh - - - -	1	30
Flies, eggs of - - - -	2	20
Flowers - - - -	2	103
—— fatal inſtance of their effluvia -	3	156
Flowering-aſh - - -	2	127
Fluids, ſecretion of - - -	1	74
Fœtus, Hippocrates's deſcription of &c.	4	121, 154
Form of plants and animals - -	4	32
Foſſils inflammable &c. - -	2	172, 203
Fountains - - - -	2	228
Fox, his ſkilfulneſs and ſubtlety -	4	105
Frogs change their ſkins - -	1	305
Froſt, ſurpriſing effects of - -	2	224
Fruit - - - - -	2	112

G

	Vol.	Page.
Gall bladder - - - -	1	71
Generation of plants &c. - -	3	264, 268
——— the ſentiments of the ancients on	4	157
Geometric analyſis - - -	4	204
Germs - - - -	3	251
Giants cauſeway in Ireland - -	2	319
Ginger - - - -	2	123
Gland - - - -	1	30
—— Pineal - - - -	1	39
Glaſs - - - -	2	328
—— diſcovery of &c. - - -	4	137, 173
—— nature and uſe of, known by the ancients	4	113
Globes, their diurnal motion - -	3	96
Glow-worm - - - -	3	24
Glutton - - - -	1	180
Gooſe and wild gooſe, ſoland &c. -	1	227
Gnats, their propagation &c. - -	2	23
Gold, chief properties of - -	2	174
Grain planted in various ſubſtances -	2	120
Gravity - - - -	3	158
Gravitation, the laws of, &c. - -	4	177
Growth of animals - - -	4	250
Gunpowder, invention of - -	2	331
——— known to the ancients -	4	139

H

Hair, various particulars of - -	1	56
Hare, ſubtleties of - - -	4	104
Halo frequently ſeen round the ſun and moon	3	11
Hands - - - -	1	72
Head, of man - - -	1	37
—— danger of dreſſing with metal pins or wire - - - -	3	47
Health, the way to preſerve it - -	1	120
Heart - - - - -	1	60

	Vol.	Page.
Heart and lungs - - -	1	146
	4	113
Hearing - - - -	1	103
Heavenly bodies, their ſituation &c. -	3	95, 97
——— what retains them in their orbits - - - -	4	177
Heat, its different degrees in the ſame latitude - - - -	2	281,
	3	49
Hedge-hog - - - -	1	171
Herrings - - - -	1	268
Hierarchies, celeſtial - - -	3	218
Hippopotamos - - -	1	277
Hippocrates, his aſſertion, that nothing is born, but what had a prior exiſtence	4	123
Honey - - - -	2	48
Horns falling off - - -	1	183
Humming-bird - - -	1	215
Hunger and thirſt - - -	1	109
Hurricanes, motion of - -	3	51

I

Jackal - - - -	1	178
Ice, Hudſon's bay, &c. -	2	222
		227
Ichneumon - - - -	1	177
Ideas, various kinds of - -	4	233
Induſtry of animals - - -	4	64
Ignes fatui - - - -	3	18
Imagination - - - -	1	133
Ink-fiſh, its properties - -	1	283
Inſect, their ſhape, eyes, heart, &c. -	2	4
—— general account of &c. - -	3	203,
		211
—— reflections on - - -	4	75
Inſtinct, natural to all creatures -	2	68
——— farther account of - -	4	49
Inteſtines - - - -	1	69
Internal fire, perſons conſumed by	2	325

	Vol.	Page.
Intellect, the operations of	4	235
Irritability of plants and animals	4	47
Iron	2	174
Iſlands, formation of	2	239
——— of Scilly	2	265
Juice, nutritive motion of	2	91
Jupiter	3	68
——— ſatellites of	3	85

K

Kennedy, his obſervations on aſtronomical chronology	3	111
Kidneys	1	71
King-fiſher	1	231
Kercher's account of a dreadful earthquake	2	309
Knowledge, different kinds of	4	246
——— its improvement by revelation	4	257

L

Lakes, fiſhes, ſalts	2	237
Lama of Peru	1	158
Lambent fire	3	19
Leaves	2	86
Legs	1	73
Lice, often found on ſalmon	2	17
Light, various particulars of	3	138
——— its inconceivable extenſion	3	148
Lightning, curing paralytic diſorders	3	40
Lima, deſtruction of	2	314
Lime	2	196
Limpet	1	284
Linnæus reduced trees and plants to claſſes	4	126
Linum aſbeſtum	2	204
Lizard of Italy	1	299
Loadſtone	1	14
——— farther account of	2	199
Locomotive faculty	4	43
Lobſters change their ſhells	1	250
Louſe peculiarities of	2	16
Luminous bodies	3	22

M

	Vol.	Page.
Mackrel, ſhoals of	1	270
Machineel-apple	2	130
Madeira iſland, thrown up by an exploſion of ſubterraneous fire	2	298
Magpy	1	219
Man, ſtature, age, origin, &c.	1	114
—— origin not diſcovered by reaſon	1	134
—— endowed with reaſon, &c. &c.	3	214
Maple-ſugar	2	136
Marmot	1	170
Mars	3	68
Medulla	1	37
Mechanical powers of the ancients	4	209
Medicine, ſcarce any new aphoriſms in, ſince the time of Hippocrates	4	111
Membrane	1	27
Memory	1	133
Mater dura & pia	1	38
Mercury	3	68
Metals, properties, generation of, &c.	2	173
Mice, fable	1	179
Meſentery	1	69
Microſcopes, the nature and uſe of, not unknown to the ancients	4	214
Microſcopic animals	2	14
Milky-way	4	190
Mines in general	2	184
Miniature, the ancient's ſkill in	4	113
Mock ſuns and moons	3	11
—— bird, American	1	222
Moloſſes	2	136
Moiſture	3	157
Monkies, aſſembly of	1	174
Monſters, formation of their birth	3	261
Moon, motion of	3	80
——— farther account of	3	183
——— has no light of its own	4	186
Moſaic-work	4	218

	Vol.	Page.
Moths, falſe, general, domeſtic, &c. -	4	71
Motion, local, voluntary, &c. -	1	113
——— farther account of - -	3	135
Mountains, various particulars of -	2	210
Mount Ætna - - -	2	286
——— Veſuvius - - -	2	290
Mules - - - -	1	166
—— generation of - - -	3	259
Multiplication of plants and animals -	4	22
Mundic - - - -	2	184
Murex, purple - - -	1	263
Muſcles - - - -	1	31
——— intercoſtal - - -	1	65
——— pearl - - -	1	263
Muſhrooms - - - -	2	134
Muſic, experiments in - - -	4	180
——— Pythagoras the firſt that gave fundamental precepts concerning - -	4	203
——— of the ancients - -	4	218

N

Natural bodies - - -	1	16
Nature, its laws - - -	1	158
——— its gifts - - -	4	5
Nerves - - - -	1	30
——— their origin - - -	3	138
Nettles, divers ſea-inſects and animals -	4	80
Niagara, cataract of - - -	2	235
Nile, its deſcription - - -	2	233
Noſtrils - - -	1	52
Nutrition - - - -	1	105
——— organs of - - -	3	247
Nutmegs - - - -	2	128

O

Occult qualities - - -	3	167
Omentum - - - -	1	70
Oocarel, of Egypt - - -	1	298
Oppoſſum - - - -	1	176

	Vol.	Page.
Organs of circulation and reſpiration -	3	248
Organical-economy - - -	1	99
Oſtrich - - - -	3	211
Oyſter - - - -	1	260

P

Palate - - - -	1	56
Palm-tree - - - -	2	126
Panniculus carnoſus - - -	1	37
Pangolin - - - -	1	172
Paragua, herb of - - -	2	123
Paſſage from inſects to ſhell-fiſh, &c. -	3	207
Paſſage from reptiles to fiſhes -	3	202
——— fiſhes to birds, birds to quadrupeds, &c. - - -	3	210
Paſſions - - - -	3	223
Palmyra, ruins of - - -	3	210
Pericardium - - -	1	61
Peritoneum pancreas - - -	1	70
Perception continued and recalled -	1	131
Perfection, corporeal - - -	3	187
Peruvian bark-tree - - -	2	127
Pepper-Shrub, of Jamaica, &c. -	2	128
Petrifying ſprings - - -	2	191
Pendulum, invented by the ancients -	4	196
Perſpectives underſtood by the ancients	4	199
Philoſophy, natural, &c. &c. - -	1	10
——— obſervations on the whole ſyſtem of	3	118
Pholades, bollani - - -	1	265
Phenomena of the ſun and moon -	3	67
Phoſphorus, properties of - -	3	149
Pilchards, a ſhoal of - - -	1	272
Pipe-worms - - - -	3	207
Plants - - - -	2	83
——— their nutrition, male and female	2	114
——— inſtances of their fecundation	3	129
Planets, magnitude of - - -	3	86
——— revolutions of - - -	3	185
Platina - - - -	2	177
Pleura - - - -	1	66

	Vol.	Page.
Port Mahon, ſtones in which muſcles are found	1	265
Polypuſes	2	55
——— philoſophical conſiderations of	3	278
Poiſon, the method uſed by the Negroes	2	131
Pool's-hole, account of	2	318
Port-Royal deſtroyed by an earthquake	2	311
Providence, particular care of	2	72
Precious ſtones	2	196
Primary Elements	3	137
Ptolemaic ſyſtem	3	69
Pulſe	4	112
Pyramids of Egypt	4	210

Q

Quadrupeds, undergo a yearly change	2	63
Queen-bee, homage paid to the	2	51
Quickſilver, properties of	2	182

R

Rabbits, proceedings of	4	96
Rain	3	5
Rain-bow	3	10
Rattle-ſnake	1	291
Ravens, couple of	1	229
Razor-ſhell	1	260
Reflections on the human body	1	78
——— in general	4	226
Rein-deer	1	164
Reptiles, particular ſorts of	1	294
Reſpiration	1	102
Rhinoceros	1	156
Rhine	2	236
Rivers	2	233
——— uncommon accounts of	2	306
Roe-buck	1	162
Rooks	1	217
Roots	2	85

S

	Vol.	Page.
Salmon, ſhoals of	1	272
Salamander	1	298
Sap	2	92
Salts, mines of	2	188
Sand, an inundation of	2	208
Sarſaparilla	2	126
Saſſafras		ib.
Saturn	3	68
Scallop	1	260
Scorpion	1	299
Sea-Nettle	1	284
Sea, many particulars of	2	231
—— water, method of making it freſh	2	249
Senſes	1	108
Senſitive-plant	3	199
Serpents, different ſorts of	1	287
——— of the water	1	295
Seeds, that increaſe	2	93
—— multiplication by	3	240
Seneca clearly deſcribed the nature of generation	4	124
Senſible qualities exiſt in the mind	4	142
——————— opinions of Deſcartes and Mallebranche on the ſubject	4	143
Shammoy	1	161
Sharks, white	1	280
Shell-fiſh	1	261
Sight	1	108
—— farther account of	3	225
Silver, neareſt to gold in ductility	2	174
Shoots, multiplication by	3	241
Silk-worm and Spider	2	8
Similar ſolid parts of the human body	1	19
Skin, dappled, &c.	1	32
Sleep	1	110
Sloth	1	181
Smelling	1	109
——— farther account of	3	155

	Vol.	Page.
Snail	1	302
Snow	3	8
—— a remarkable deliverance from	2	314
Soul, its immortality	1	133
—— of brutes	1	151
—— a farther inquiry concerning the	3	214
Solidity	3	134
Soles, their generation	1	268
Solitary flies, ſagacity of	4	53
Societies of animals	4	57
Sound	3	143
Spirits, and divine things	1	16
—— animal	1	73
—— farther account of	3	256
Spleen	1	71
Spider, various ſpecies of the	2	8
Squirrel	1	169
Stomach	1	67
Stone, grand operation or the	4	116
Stork, an account of a ſtrange one	1	223
Steel	2	182
Stones	2	189
St. Helmo's fire	3	43
Storm, on the Fetter, a lake of Gothland	3	53
Stars, fixed, number of, &c.	3	93
—— difference of their magnitudes accounted for	4	198
Stag, ſubtleties of	4	104
Submarine graſs	2	122
Subterraneous trees in Italy, Ireland, &c.	2	269
—— fire, of a harmleſs nature	2	319
Sugar, maple	2	136
Sun	1	16
— farther account of the	3	77
— advantages of the	3	97
— need of his abſence by night	3	100
— ſcriptural account of the	3	111
— various conjectures concerning the	4	201
Swan	1	227
Syſtem, Ptolemaic, Copernican, &c. &c.	3	69
—— of Copernicus deſcribed	4	182

T

	Vol.	Page.
Tad-poles	1	301
——— their transformation	2	64
Taſtes	3	157
Taſting	1	109
Tapeſtry-bee	4	181
Tape-worms	1	303
Tarantula, muſic the only remedy for the bite of	2	11
Teeth	1	55
Tellina	4	78
Teneriffe, peak of	2	303
Terreſtrial beings	3	186
Tertullian deſcribes the nature of generation	4	124
Thames	2	234
Thigh	1	73
Thorn-back	1	283
Thunder	3	12
——— the moderns divided in their opinions concerning	1	158
Thorax	1	65
Tides	2	246
Toad	1	306
Tongue, a perſon ſpeaking without a	1	53
Tortoiſe	1	281
Torpedo	1	283
Tranſition from vegetables to animals	3	199
Transformation	3	233
Trees will grow inverted	2	116
Trigonometry, owes its origin to Hipparchus	4	204
Tunnies	1	271
Turbot	1	273
Turtle	1	281

U

Underſtanding	1	133

	Vol.	Page.
Underſtanding, bounds and extent of -	4	233
Union of ſoul and body - -	1	134
Univerſe - - - -	3	180
——— harmony and univerſal connection of the - - - - -	3	184
Uvula - - - -	1	57

V

Vacuum - - - -	3	133
Valves of the heart, diſcovered by Father Paul - - - -	4	113
Vapours - - - -	3	3
Vegetables, regeneration of - -	3	244
——-——— farther account of -	4	152
Veins - - - -	1	29
—— lacteal - - - -	1	70
Venus - - - -	3	68
——- farther account of - -	3	183
Vipers - - - -	1	290
Volcano's - - - -	2	302
Vultures - - - -	1	217

W

Water-withy - - -	2	129
Water, chief properties of, &c. -	2	221
——— luminous in the Gulf of Venice	3	20
——— ſpouts on the coaſt of Barbary	3	53
Whales, their manner of propagating, &c.	1	273
Wild-pine - - - -	2	128
Will - - - -	1	133
Wind-pipe - - - -	1	57
——— farther account of -	1	151
Wind, ſeveral particulars of -	3	49
Wood-pecker -	1	220
Wood of plants - - -	2	85
World - - - -	2	74
Worlds, multiplicity of - -	4	191

	Vol.	Page.
Worms, that feed on ſtones - -	1	304
—— that multiply by ſlips - -	4	124
—— the regeneration of - -	4	4

Z

Zebra - - - -	1	167
Zoophytes - - - -	3	271

FINIS.

Special
collec.

BW264
.W4S8
1810
v. 4